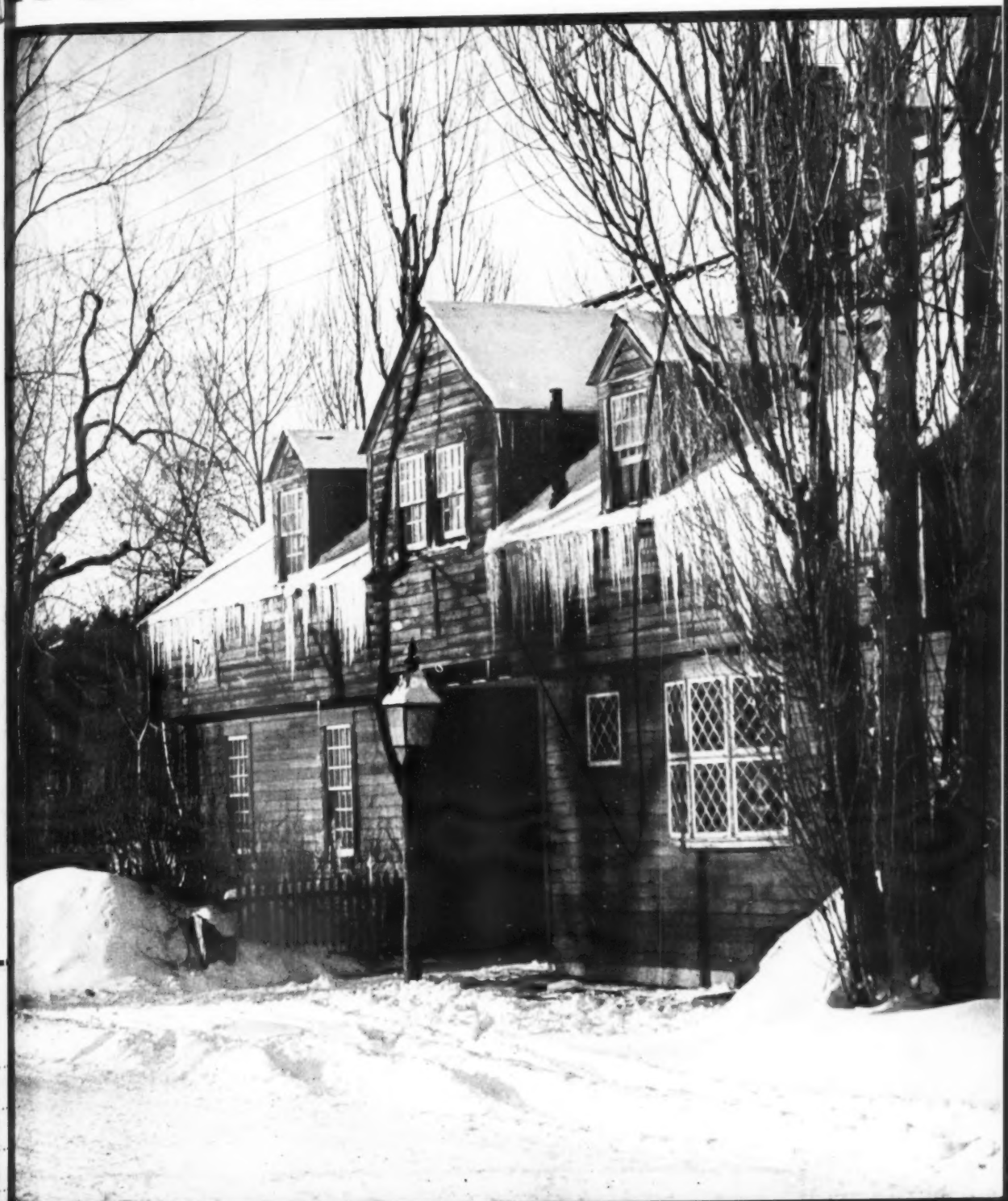
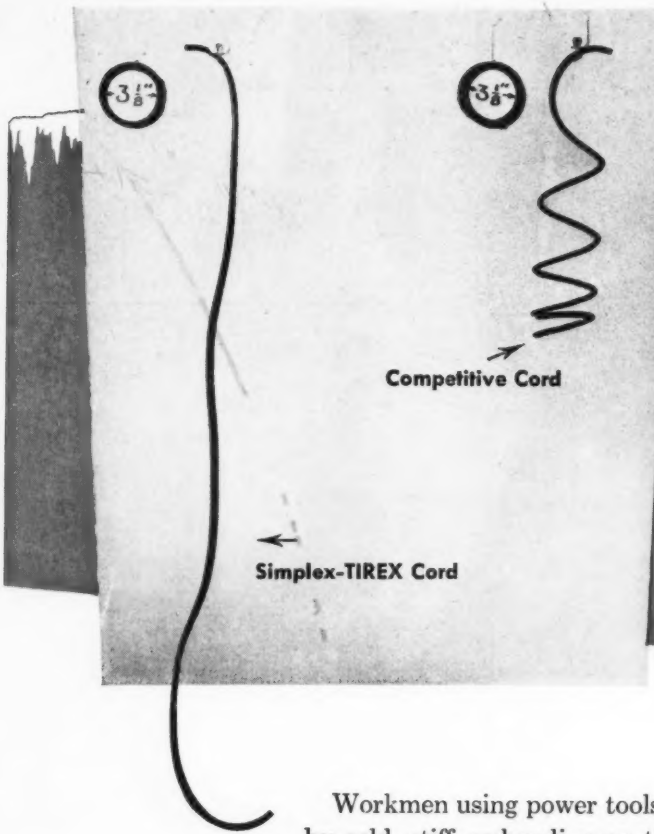
TECHNOLOGY DEPT.

TECHNOLOGY REVIEW

December 1955





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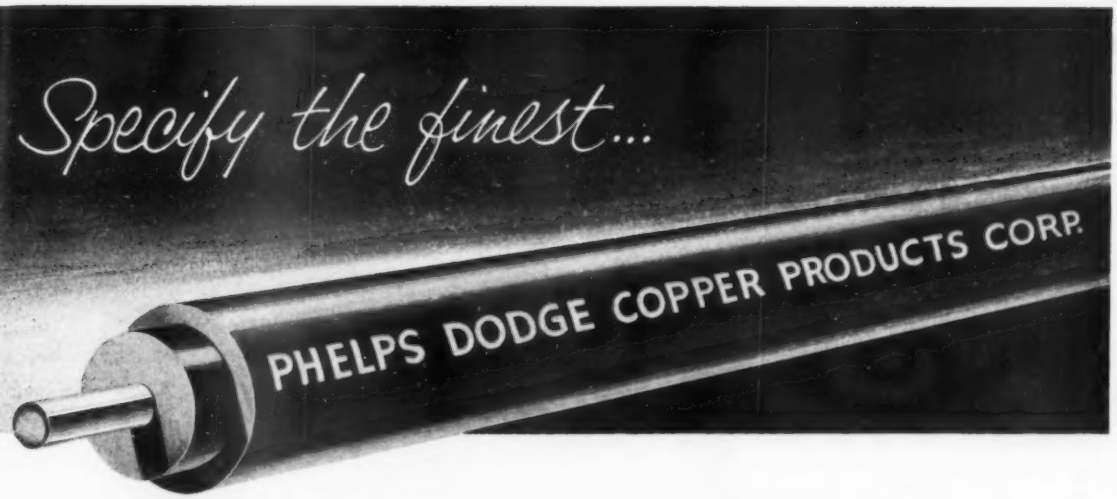

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Rely on this highest quality cable—it works where others fail

The term "RR" is only a name, not an assurance of quality. Instead of ordering just "RR" cable, insist on Phelps Dodge Habirite-Habirprene—developed through years of experience in designing and making high voltage cables. Habirite-Habirprene exceeds the trade's highest standards of quality and reliability.

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- Much greater resistance to ozone—present around high voltage equipment.
- Much greater mechanical toughness affording maximum protection against damage from tools, stones and other installation hazards.
- Better electrical properties—giving a greater safety factor in operation.
- Maximum uniformity of finished product—due to controllable uniformity of raw materials.
- Elimination of seams which cause weak spots—through use of Phelps Dodge extrusion insulating process.

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When you specify Habirite-Habirprene, you are assured of getting "RR" cable with the utmost in safety and durability. Habirite-Habirprene is the result of Phelps Dodge's rigid quality standards, long experience, expert engineering and vast facilities.

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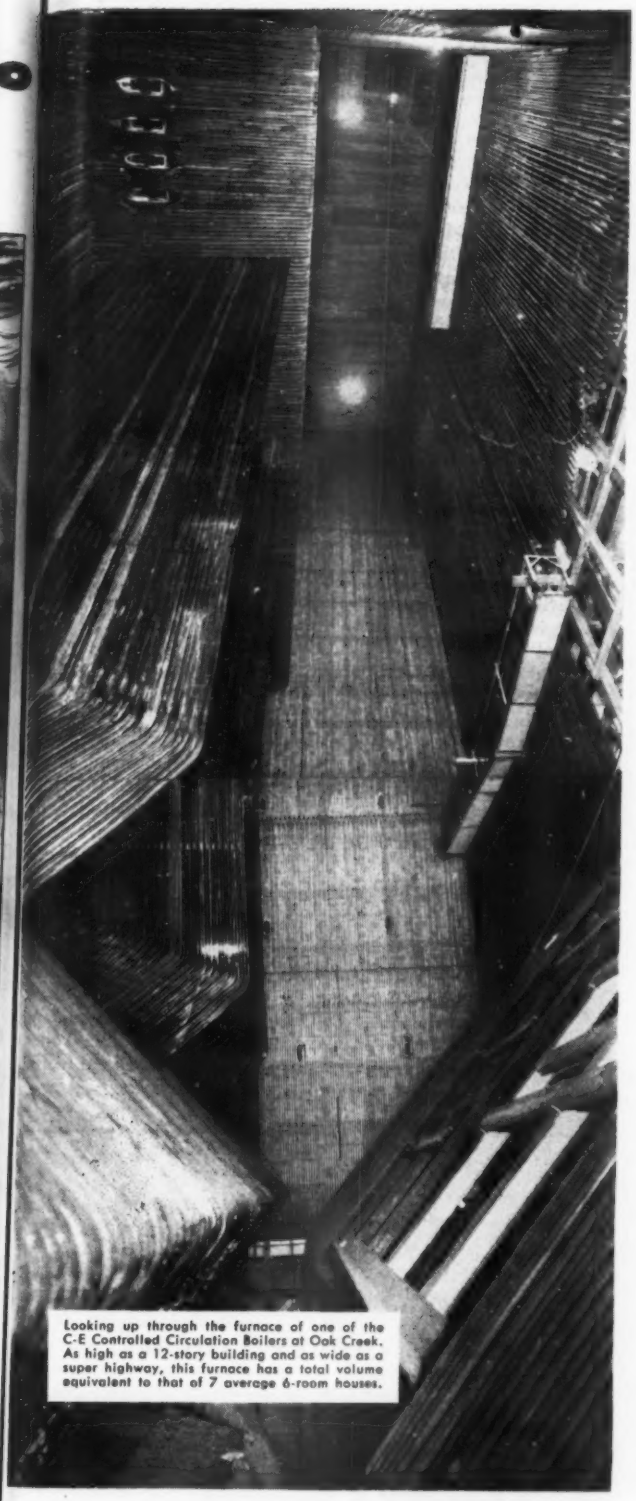

Looking up through the furnace of one of the C-E Controlled Circulation Boilers at Oak Creek. As high as a 12-story building and as wide as a super highway, this furnace has a total volume equivalent to that of 7 average 6-room houses.

Wisconsin
Electric Power Company

A STORY OF PIONEERING

In the annals of America's great industrial achievements, a few names stand out. They are the pioneers, the companies whose work has advanced technology in major steps. Such a company in the field of power generation is the Wisconsin Electric Power Company. Its first big pioneering step was taken 35 years ago when it built . . .

A power plant that made Milwaukee famous

In 1920, the use of pulverized coal as a fuel for boilers was virtually unknown in the utility industry. Wisconsin Electric, after 5 years of development work in an older plant, took the bold step of designing a large new power station (the Lakeside Station) for the exclusive use of pulverized coal. Lakeside not only proved the practicability of pulverized coal but became the world's most efficient power station. Power engineers from all parts of the country and abroad came to Milwaukee to observe and learn. Pulverized coal made a major contribution to the economy of power generation and has long since become the universal method of burning coal in electric power stations.

Wisconsin Electric took its next big forward step in 1930 when it started construction of its Port Washington Station.

Port Washington set new efficiency record

Port Washington was unique among American power stations in that it not only set a new efficiency record during its first years of operation but maintained its position as *the world's most efficient power station* for 13 years. It had other claims to fame as well. Its boilers were the largest high-pressure boilers then built and established new reliability records in service.

And then came Oak Creek

Now Wisconsin Electric has erected another landmark on its "road of achievement" with its new Oak Creek Station, placed in service in late 1953. Oak Creek, like its famous predecessors in the Wisconsin system, introduces important innovations in design and is noteworthy among the outstanding power stations of today.

• • •

And what is Combustion Engineering's part in the Wisconsin Electric story? Just this. Combustion pioneered pulverized coal burning from the manufacturer's side, and designed and built all the pulverized coal equipment installed at Lakeside, Port Washington and Oak Creek. It supplied the boiler units installed in the Port Washington Station. And at Oak Creek, Wisconsin Electric now has in service two of Combustion's most advanced type of controlled circulation boilers, with a third being installed.

Wisconsin Electric, pursuing its forward looking policy, was among the first to recognize the special advantages of the controlled circulation boiler which, in the past five years, has achieved an acceptance by utilities never before accorded a basically new design. B-856

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GEARS

THE TABULAR VIEW

Industrial Liaison. — In operation since 1948, the M.I.T. Industrial Liaison Program, established to provide close technical contact between M.I.T. and industrial research, is described (page 87) by EUGENE B. SKOLNIKOFF, '49. Mr. Skolnikoff received the S.B. and S.M. degrees in 1950 (Course VI-A), then studied philosophy and economics as a Rhodes scholar at Oxford University from which he received the B.A. degree in 1952. He has spent two and one-half years with the Industrial Liaison Office at M.I.T.

Excellence First. — In "Engineering Education and National Spirit" (page 91), JULIUS A. STRATTON, '23, makes a strong case for that kind of engineering education that develops "personal responsibility . . . with ready willingness to minister to the public welfare." Dr. Stratton has had a distinguished career as professor of physics, member of the staff of the Radiation Laboratory, head of the Research Laboratory of Electronics, and since 1952 as vice-president and provost of M.I.T.

Distaff Doings. — Ever wonder what makes young ladies want to study at M.I.T. — how their technical training benefited them in later years? Answers to these and other interesting questions about Alumnae are given (page 94) from the women's point of view. The article on coeds summarizes the results of a survey made by the Registration Committee of the M.I.T. Women's Association in co-operation with the Office of the Dean of Students. For the preparation of this report, as well as for the article in this issue, The Review is indebted to: Ruth L. Bean, Assistant Dean of Students, and the following ladies who served as officers of the M.I.T. Women's Association when the survey was conducted in 1953: Mary E. Guinan, 2-44, President; Gladys P. Lyons, 6-45, Vice-president; Katherine S. (Mrs. Harold L.) Hazen, '28, Recording Secretary; Grace G. Farrell, '29, Treasurer.

Good Riddance. — Aided by widespread vaccination practices, medical science has virtually eliminated smallpox from the American scene. But, as JAMES A. TOBEY, '15, points out (page 97), this was not always so, and the disease was often a scourge in America. Dr. Tobey has achieved an outstanding career in public health and public health law.

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MU4-11

CLIMAX MOLYBDENUM

EDUCATIONAL NEWS DIGEST

1. About one year ago a Corporate Alumnus Program was established by the General Electric Educational and Charitable Fund. Through this new program, the Fund agreed to match, under certain conditions, contributions up to $1,000 by employees of General Electric to the colleges and universities from which they held degrees.

We know now that CAP will continue in 1956. A new provision interprets *alumnus* as most colleges do: the Fund will match gifts made to any college at which an employee was *in attendance* one year or more. An employee may now contribute to a college at which he did not complete requirements for a degree.

Wide range of participation in the Program is shown by the fact that gifts have ranged all the way from $1 to the limit of $1,000. On October 1, there were 3,113 contributions to 285 colleges, totaling $116,877; any alumnus who reads his mail knows that the modest gifts count as they never counted before.

* * *

2. A fifth university will start offering the G-E Fellowship Program for high-school teachers in the summer of 1956; Syracuse University will conduct a program in science for 50 high-school teachers. This particular program—like those in science and math, in Union, RPI, Case, and Purdue—will be underwritten by General Electric from the time the teacher leaves home till he returns six weeks later. These five challenging programs are at graduate levels. Our participation also includes scheduled lectures and trips to plants and laboratories to hear and observe how mathematics and science are used in modern business.

The Teacher Fellowships Program began in 1945 at Union, and that summer there was but one session of 50 teachers. By now, approximately 1,350 teachers have had the benefit of these special programs, have themselves been taught by distinguished professors, and have in turn brought to their several hundred thousand students the undebatable truth that the well-grounded student will soon find the pages of his textbook coming to life in his chosen career.

* * *

3. We attempt in our various plant locations to help our people help themselves. Here's a variation of a plan, now in effect at Schenectady: 35 young men, who might otherwise have foregone going to college and earning a technical degree, are now at work as apprentices at General Electric and in attendance at Union College. These young men were graduated in the top half of their high-school class, came out well on the College Board tests, had an academic diploma with 16 full credits (almost half of them in English and math), and demonstrated a genuine desire for a college education.

These men are full-time apprentices in drafting, machining, pattern making, and metal founding. At the end of 8,000 hours of apprenticeship, they will have completed, after business hours, and with tuition paid by the Company, two full years of college. They may then apply for a leave of absence to work for a degree on a full-time basis, or continue their educations at night, still working full time for G.E.

* * *

4. A new booklet, GROWING WITH GENERAL ELECTRIC, is designed to do two things: to introduce General Electric's 10 Programs for college graduates to potential employees and to serve generally as a guidance tool in the hands of alumnus, parent, and instructor. Each Program is presented on a single page in such a way that the reader can determine immediately what "majors" must show on the student's record if he wishes to be considered for admission to that Program. Since the matter of prerequisites looms up as a mighty problem to youth, and since the stated requirements are, with minor variations, generally applicable in industry, such information should help the alumnus in his important function of youth guidance.

EDUCATIONAL RELATIONS SERVICES, GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

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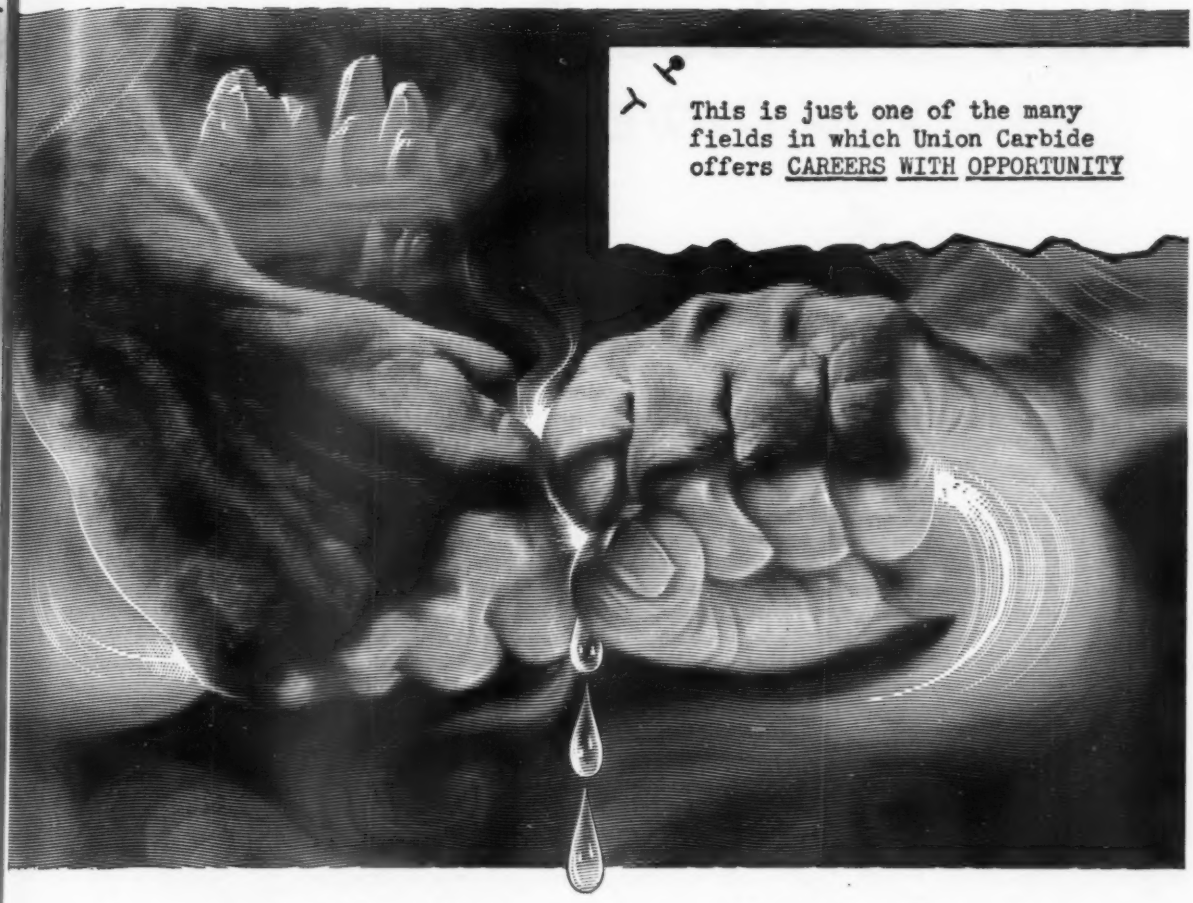

Intense Cold...Fierce Heat...Terrific Pressure

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HEAT SO FIERCE it makes steel boil . . . cold so intense it turns the very air to liquid . . . pressure so great it has the force of 600 hurricanes . . . space so "empty" that nothing could live in it.

THESE FORCES OF NATURE are used by industry in making so many of the things we take for granted today. The electric arc furnace—6,000 degrees hot—is the birthplace of alloying metals that go into stainless steel and other fine steels. Oxygen, so vital to medicine and industry, is extracted from air made liquid when cooled to more than 300 degrees below zero.

ETHYLENE GAS SQUEEZED under pressure of 15 tons per square inch changes into polyethylene. This remarkable plastic is used to make such familiar things as unbreakable nursing bottles, squeeze-spray containers, and transparent wrappings. Exposing natural gas to terrific pressures and the "nothingness" of vacuum have been key steps in making hundreds of new chemicals during the last 20 years.

THESE ARE BUT A FEW examples of how industrial scientists such as those of Union Carbide have discovered how to use the forces of nature to create the new processes and products necessary to America's progress.

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On cleared highways, its flat tread runs more quietly, smoothly. Suburbanite cleats are flexible, so the tread cleans itself as it rolls—it's always ready to grip. Also available in a conventional winter tire for use with tube.

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THE TECHNOLOGY REVIEW

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EDITED AT

THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

H. Armstrong Roberts

"Oh, we make our own dormitory rules."

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VOL. 58, NO. 2 **DECEMBER, 1955**

CONTENTS

OLD COACH HOUSE IN WINTER
PHOTOGRAPH BY RAYMOND E. HANSON ..... THE COVER

THE GETTYSBURG ADDRESS
PHOTOGRAPH BY EWING GALLOWAY, N. Y. .....FRONTISPIECE 82

THE M.I.T. INDUSTRIAL LIAISON PROGRAM
BY EUGENE B. SKOLNIKOFF 87

The future of industry depends upon the products which our colleges turn out. In the Industrial Liaison Program, industry and education have developed a highly stimulating program of mutual benefit and support

ENGINEERING EDUCATION AND THE NATIONAL SPIRIT
BY JULIUS A. STRATTON 91

Engineering education is called upon not only to train men to a high degree of technical competence, but also to develop in them a high sense of obligation to serve man's well-being

THE M.I.T. COED — THEN AND NOW . . . .BY MEMBERS OF THE REGISTRATION COMMITTEE, M.I.T. WOMEN'S ASSOCIATION 94

A few young ladies have always been members of the M.I.T. student body. A statistical summary of the degrees they received, the professional work they did, and the use they made of their Technology training in later life is presented

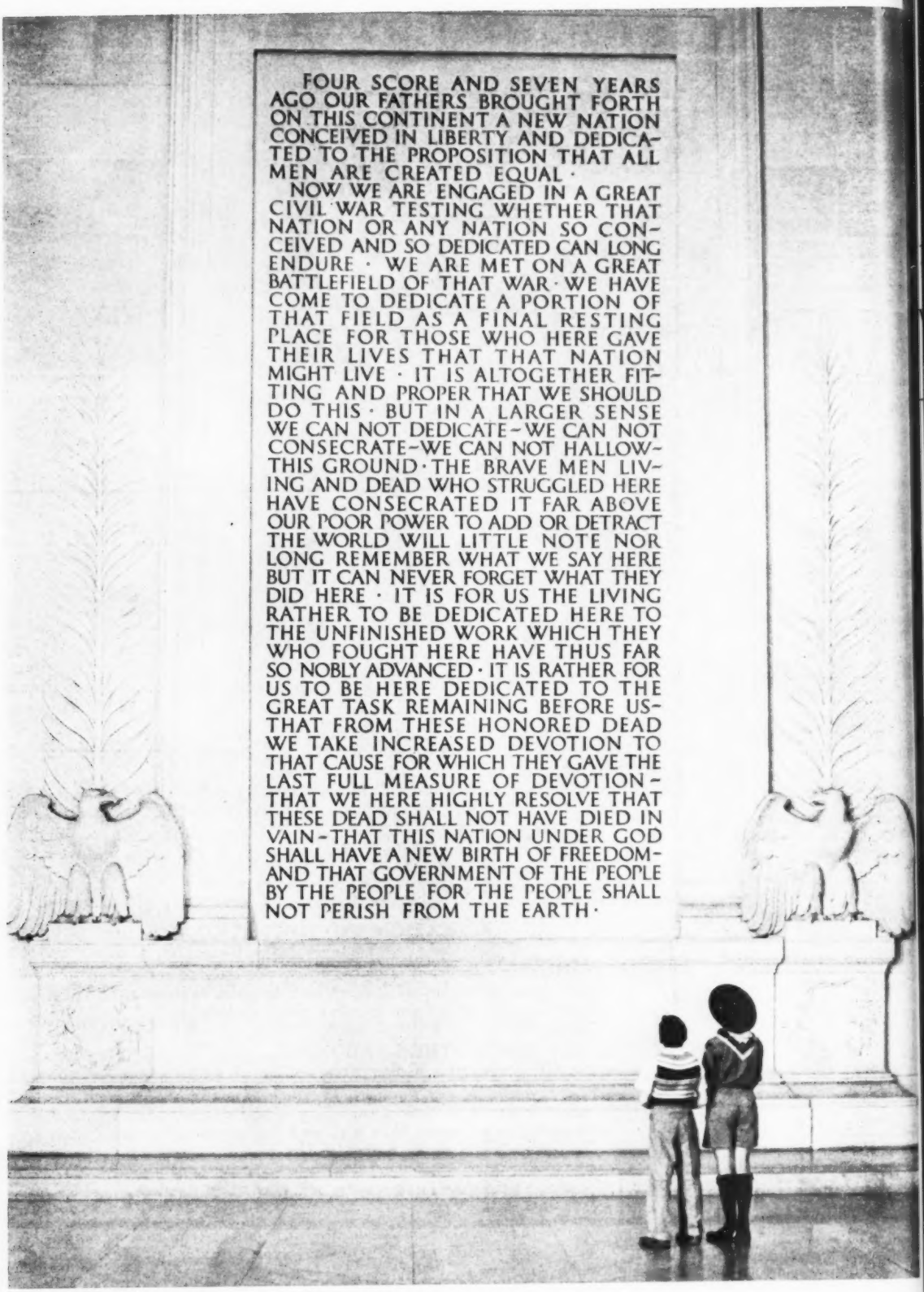
WHEN SMALLPOX FLOURISHED IN AMERICA
BY JAMES A. TOBEY 97

Now virtually unknown because of preventive vaccination, smallpox has frequently been a scourge to the populace of North and South America

THE TABULAR VIEW • *Contributors and Contributions* 76

THE TREND OF AFFAIRS • *News of Science and Engineering* .. 83

THE INSTITUTE GAZETTE • *Relating to the Massachusetts Institute of Technology* 99


FOUR SCORE AND SEVEN YEARS AGO OUR FATHERS BROUGHT FORTH ON THIS CONTINENT A NEW NATION CONCEIVED IN LIBERTY AND DEDICATED TO THE PROPOSITION THAT ALL MEN ARE CREATED EQUAL ·
NOW WE ARE ENGAGED IN A GREAT CIVIL WAR TESTING WHETHER THAT NATION OR ANY NATION SO CONCEIVED AND SO DEDICATED CAN LONG ENDURE · WE ARE MET ON A GREAT BATTLEFIELD OF THAT WAR · WE HAVE COME TO DEDICATE A PORTION OF THAT FIELD AS A FINAL RESTING PLACE FOR THOSE WHO HERE GAVE THEIR LIVES THAT THAT NATION MIGHT LIVE · IT IS ALTOGETHER FITTING AND PROPER THAT WE SHOULD DO THIS · BUT IN A LARGER SENSE WE CAN NOT DEDICATE - WE CAN NOT CONSECRATE - WE CAN NOT HALLOW - THIS GROUND · THE BRAVE MEN LIVING AND DEAD WHO STRUGGLED HERE HAVE CONSECRATED IT FAR ABOVE OUR POOR POWER TO ADD OR DETRACT THE WORLD WILL LITTLE NOTE NOR LONG REMEMBER WHAT WE SAY HERE BUT IT CAN NEVER FORGET WHAT THEY DID HERE · IT IS FOR US THE LIVING RATHER TO BE DEDICATED HERE TO THE UNFINISHED WORK WHICH THEY WHO FOUGHT HERE HAVE THUS FAR SO NOBLY ADVANCED · IT IS RATHER FOR US TO BE HERE DEDICATED TO THE GREAT TASK REMAINING BEFORE US - THAT FROM THESE HONORED DEAD WE TAKE INCREASED DEVOTION TO THAT CAUSE FOR WHICH THEY GAVE THE LAST FULL MEASURE OF DEVOTION - THAT WE HERE HIGHLY RESOLVE THAT THESE DEAD SHALL NOT HAVE DIED IN VAIN - THAT THIS NATION UNDER GOD SHALL HAVE A NEW BIRTH OF FREEDOM - AND THAT GOVERNMENT OF THE PEOPLE BY THE PEOPLE FOR THE PEOPLE SHALL NOT PERISH FROM THE EARTH ·

Ewing Galloway, N.Y.

The Gettysburg Address

A classic in American literature, Abraham Lincoln's famous address delivered on November 19, 1863, is shown here as it appears on the south wall of the Lincoln Memorial at the nation's capital in Washington, D.C.

THE
TECHNOLOGY REVIEW

Vol. 58, No. 2 December, 1955

The Trend of Affairs

Science — A Force for Peace

SCIENCE is both a deterrent to war and a force for peace, James R. Killian, Jr., '26, President of M.I.T., declared at a luncheon of the Nutrition Foundation at the Plaza Hotel in New York on November 2. But science also faces its own hazards. "The hazard we face is that science will be so identified with destruction and so hemmed in by security considerations that its real significance will be lost, its ranks weakened, and its creativity diminished," Dr. Killian said.

"If American science is to continue to prosper, if it is to continue to attract to it its proper complement of creative and gifted minds, scientists must combat the notions that science and engineering are incompatible with the great humanities disciplines, and that they are narrowly materialistic and destructive of human values."

By increasing the power of weapons, President Killian asserted, science "may be helping . . . to convince the nations of the world that total war is no longer a possible instrument of national policy for anybody." But at the same time it is improving man's "health, his standard of living, his standard of understanding, and his opportunities for spiritual growth." Science is therefore a force for peace, declared Dr. Killian, who added:

> Our great problem and opportunity now are to let science be its true self and thus to realize its full potential for good. We live in a period marked by both subtle and gross assaults on intellectual life. The whole domain of science has been represented as endangering man's noble aims and ends. In the face of the practical responsibilities which rest in science for our security and our material welfare, it is all too easy for people to become bemused by the sophistry that science is inimical to the spiritual ends of life and for them to fail to understand that instead, it is one of man's most powerful and noble means for searching out truth and augmenting man's dignity by augmenting his understanding.
>
> Scientists have an obligation to make this true character of science better understood and to do so, not by arrogant advocacy of science and technology as the only means to increase our understanding and well-being, but by the balanced and tolerant presentation of the scientific spirit as one of the great and powerful methods by which man can increase his knowledge and understanding and still remain humble and ennobled before the wonder and majesty of what he does not understand.

President Killian's important message may appear to be quite unnecessary and superfluous to readers of The Review. The public at large, however, can hardly be expected to be familiar with the general aims and tenets of science.

One Man's Meat

IT is much less expensive for mankind to eat directly plant crops such as vegetables, fruits, or grains, rather than to feed the plant crops to animals and then consume the animals' meat, milk, or eggs. That is why in areas where poverty is prevalent, as in sections of the Orient, the people eat very little animal foods. Unfortunately dietaries consisting mainly of plant foods not only lack the gustatory delights provided by meat, fowl, and dairy dishes but also lack nutritional quality. For animal foods provide, in addition to calories, proteins of high quality as well as abundant beneficial minerals and vitamins.

Although all farm animals are quite wasteful in their conversion of plant foods to animal foods suitable for human consumption, some are less so than others. Pigs are the most efficient meat-making machines. They convert about 20 per cent of the feed they eat (measured in terms of calories) into parts of their bodies edible by mankind. In contrast, on this basis, steers and lambs convert to food only

about 4 per cent of the feed they consume. Hence the housewife finds that pork costs less than beef or lamb. The price differential she encounters is, however, much smaller than the fivefold difference in efficiency of meat production just stated. This is true because pig rations are more expensive than steer or lamb rations. The pig, a nonruminant, must be provided with feeds, such as corn, that could be eaten directly by the human being and hence have substantial market value. But cattle and sheep are ruminants; they thrive on rations largely useless as human food, such as straw, by-products from human food production such as grain mill offal, or grass grazed from land too infertile, arid, or rough to support any crop the human being can eat.

Efficient conversion of animal feed to human food also explains why milk and its products are so economical. The dairy cow does require somewhat more feed than the pig to produce a given amount of human food – nine and three-tenths pounds of feed for milk as against seven and seven-tenths pounds for pork to produce enough calories to maintain a human being for a day. But the dairy cow thrives with as much as three-quarters of her ration consisting of roughage and forage useless as human food. That is why milk, even in the form of products like cheese where the cost of considerable processing has been added, is a low-cost food despite its exceptionally high nutritional quality.

Thus pigs and dairy cows are the most efficient converters of animal feed into human food, beef cattle and sheep the least efficient. Dead center of the spectrum lies the chicken. Whether used as a source of eggs or of meat, chickens require more than twice as much feed as pigs or dairy cows, and less than half as much feed as steers or sheep, to produce a given quantity of human food. But chickens, like pigs, require virtually all of their nourishment in forms that can serve as human food.

The chicken provides cogent proof of a crucial fact in relation to efficiency of conversion of animal feed to human food: such efficiency is not rigidly inherent in a species nor immutable for all time. Rather it may be improved markedly by improvement of the animals through breeding, and by advances in animal maintenance and management. In 1932 an agricultural experiment station study of broiling chickens revealed that the birds had consumed a trifle over three and seven-tenths pounds of feed for each pound of body weight at the age of 12 weeks, at which time the chickens weighed about two and a half pounds. A comparable study in 1951 reported that birds which were 12 weeks old weighed much heavier – about four pounds; they had eaten only a little over two and nine-tenths pounds of feed for a pound of body weight. Today broilers can be raised to market weight in about 10 weeks; in the 1930's, a period of 15 or so weeks were needed. Hence besides the saving in feed there is a saving in labor and farm facilities.

Thus the picture of plenitude enjoyed by American consumers today may be expected to brighten still further as improvements in farm animals, and advances in their management, continue to increase the availability of meat, milk, and eggs.

The Aerothermopressor

BASICALLY, the aerothermopressor is a duct within which atomized water evaporates into a high-speed stream of high-temperature gas. The net result is a rise in total pressure (static pressure plus dynamic pressure) of the gas stream. Thus the aerothermopressor performs the same function as a reciprocating or rotary compressor, but requires only a simple structure having no moving parts.

The history of inventions shows that, almost without exception, the theory of a device comes after the conception of its mechanical arrangement. The aerothermopressor seems to represent an instance in which theory reveals practical possibilities.

When a gas is contained in a tank of fixed volume, it is well known that its pressure will fall if the tank is cooled. The startling fact revealed by theoretical gas dynamics is that the cooling of a gas stream flowing in a duct at high speed produces a rise in total pressure. The static pressure, on the other hand, may either increase or decrease, depending on whether the gas speed is respectively subsonic or supersonic.

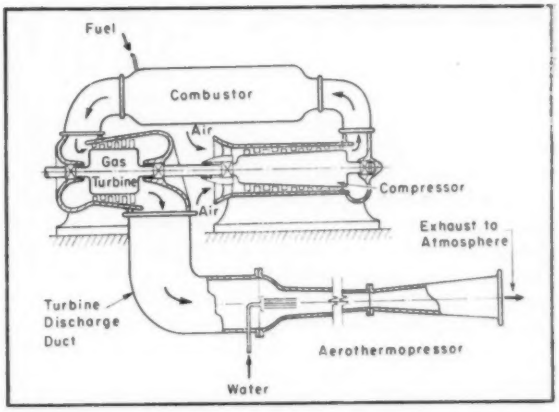
Of the various applications which have thus far been considered, the use of the aerothermopressor for improving both the performance and the characteristics of a gas turbine plant is one of the most promising. For example, when placed at the exhaust of the power turbine in the simple gas turbine cycle, the aerothermopressor is supplied (at no expense, as it were) with a stream of air so hot that appreciable evaporative cooling, and hence an appreciable increase in total pressure, can occur. If the aerothermopressor increases the total pressure and also discharges to the atmosphere, it follows that the stagnation pressure at the turbine exhaust must be reduced below atmospheric pressure. Thus the aerothermopressor is somewhat analogous to the condenser of a conventional steam power plant. Without any change in the fuel flow, air flow, or machinery size, the net power is increased.

Simple as it may seem in outward appearance, the events transpiring with the aerothermopressor are complex and tightly interwoven. The hot air coming from the turbine is accelerated by a converging nozzle into the evaporation section at a Mach number (ratio of gas speed to sound speed) of about 0.7. There the water is injected at low velocity into the gas by multiple jets, and is disrupted into an atomized spray by the shearing action of the gas stream. After the droplet cloud is formed, it is rapidly accelerated by the aerodynamic drag forces exerted by the air on the droplets; it receives heat from the high-temperature gas (and thus its temperature tends to rise); and it evaporates into the gas, with the latent heat supplied tending to keep the droplets cool. The aerodynamic drag and steam generation tend to reduce the total pressure of the gas, while the heat transfer tends to increase it. After the gas stream is nearly saturated with water vapor, it enters a diffuser, where it is decelerated and where dynamic pressure is exchanged for static pressure. The stream is discharged from the diffuser exit to the atmosphere.

From what has been said before, it is evident that, to get a useful result from the aerothermopressor, the beneficial effects produced by the loss of heat from the gas to the droplet cloud must be made to outweigh the combined harmful effects of pipe friction, aerodynamic drag of the droplet cloud, and steam generation.

In large gas turbine units it appears likely that the aerothermopressor will be able to produce a total pressure increase of about 20 per cent. This means that the pressure at turbine exhaust will be about 17 per cent less than atmospheric. For power plants with compressor and turbine efficiencies of 85 per cent, this will produce about a 20 per cent increase in power for the same fuel consumption and machinery size. For plants with component efficiencies of only 75 per cent, the increase in power will be nearer 50 per cent.

With partial sponsorship of the Office of Naval Research and the Bureau of Ships, research has been proceeding at M.I.T. since 1946 on the complex aerodynamic, thermodynamic, heat transfer, and mass transfer phenomena occurring within the aerothermopressor. The research, which is still in progress, has been directed by Ascher H. Shapiro, '38, Professor of Mechanical Engineering, with the support of Kenneth R. Wadleigh, '43, Associate Professor of Mechanical Engineering, Arthur A. Fowle, 10-44, Assistant Professor of Mechanical Engineering, Bruce D. Gavril, '49, Division of Industrial Coöperation, and Alve J. Erickson, '51, Assistant Professor of Mechanical Engineering.



Basically a duct in which flow a high-speed stream of gas and a cloud of water droplets, the aerothermopressor may be placed at the exhaust of a power turbine, or between the combustor and the turbine. In either case the performance and characteristics of the gas turbine plant can be improved.

Titanium

Long known as an ingredient of white paints and smoke screens, titanium is beginning to take on a new role — that of a prime structural metal. Although the metallurgy of this metal is still in its early stages, some titanium alloys are showing strength-to-weight ratios almost twice that of alloy steel. Its properties, moreover, continue to compare favorably with those of the alloy steels as the operating temperature is increased. Thus it is in a different category than the aluminum alloys, which have little role in the high-temperature zones of jet engines or in those structural regions of missiles and aircraft which, as Mach numbers rise, will be exposed to aerodynamic heating. As compared to the alloys of aluminum, titanium alloys can be heat-treated to ultimate tensile strengths, approaching 200,000 pounds per square inch.

The key to the intense interest being shown in this metal lies in two numbers that are standard in describing an element; its specific gravity and its melting point. Titanium is little more than half the weight of iron. Its strength is comparable. Its melting point is substantially higher. Generally, it is a potentially useful metal in applications now requiring stainless steel. Tough, extremely resistant to abrasion and corrosion, especially from chlorides, titanium also has the unusual property of offering more protection as armor plate than the most highly developed steels. Its extreme fluidity when molten is proving of aid in the development of welding techniques. On the other hand, it has been found hard to grind and machine.

Although the future for this metal is bright, the present is beset with metallurgical and fabricating difficulties, for the art of refining and handling titanium is very much in its infancy. Titanium is a viciously difficult metal to extract from its ores. These ores are plentiful, for titanium is the 10th most abundant element in the earth's crust. It is approximately 100 times as common as zinc or lead. But it will combine, when hot, with nitrogen, oxygen, hydrogen and many other elements, generally with serious effects on its properties. When molten, it can pull oxygen out of the refractory bricks used to line melting furnaces for other metals. Titanium therefore is refined today in highly specialized equipment under vacuum or a blanket of noble gas.

The processes now in use yield a sponge of titanium which must be melted in electric arc furnaces under protective atmospheres. The resulting ingots are trimmed, remelted, and subjected to such alloying and fabrication as is required. While falling, the cost of metal obtained by such batch techniques is currently so high as to put it economically out of reach of many commercial applications. Continuous methods for producing this metal, either as a powder or an ingot, are under study. Predictions have been made that the present cost of the raw metal can be cut at least in half.

The present production picture is confused. Most of the metal is being produced under contract to the government in amounts that exceed immediate consumption. But present applications are almost all experimental. Its use in only a few items in large-scale production would quickly exhaust present capacity. Aside from its use in forgings and sheets for air frames, bolts and other fastenings of titanium alloys are available. These show strength-to-weight ratios almost twice that of alloy steel, and are claimed to be capable of saving up to 1,000 pounds of weight an air frame, if used freely.

Image Intensification

ONE of the major problems of methodology in scientific research, particularly in biology and medicine, is the detection of minute quantities of radiation. As long as we are required to measure only the amount of radiation, several efficient methods are available. In the region of visible light, for example, the photomultiplier tube and photocounter yield satisfactory results, whereas in the region of x-rays and gamma rays, counters (of the Geiger, scintillation or crystal type) may be used. However, if we wish to detect radiation in a two-dimensional image – such as is needed in medical radiography or in x-ray diffraction – the spatial distribution as well as the amount of radiation must be determined and new methods have to be worked out.

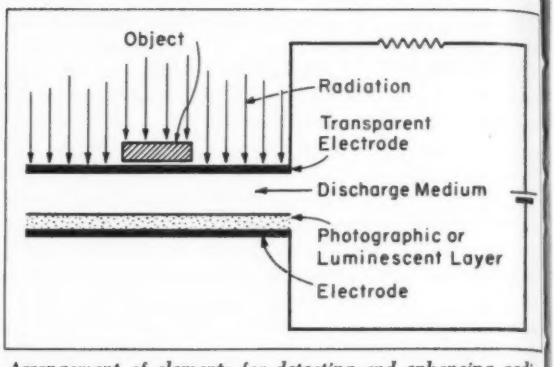
The development of a method for image detection and intensification has been the object of a project carried on by Kurt S. Lion, Associate Professor of Applied Biophysics. This work has been done in the Institute's Department of Biology, under contract with the Office of Naval Research and the support of the Signal Corps.

As indicated in the diagram, the image is formed on a photographic emulsion or luminescent layer by an object interposed in the path of the incident radiation. The radiation to be detected falls upon a chamber consisting of a transparent electrode, a discharge medium (such as a gas) in which an electric discharge occurs under the influence of an applied voltage, a photographic or luminescent layer which responds to the discharge, and a second electrode for collecting the discharge particles.

The chamber acts as a parallel plate Geiger counter in which incident radiation causes the liberation of primary electrons. The primary electrons are accelerated by the applied field which is sufficient to produce ionization by impact. Under appropriate conditions, an avalanche takes place in which each primary electron produces an enormous number (of the order of 10^8) of electrons and ions. These powerful discharges produce well-defined local marks on the photographic emulsion or luminescent layer in accordance with the amount and distribution of radiation absorbed by the object.

Although the arrangement of the apparatus for accomplishing image intensification is ideally simple, the theory of operation is relatively complex and the experimental difficulties involved in the analysis of the image intensification are considerable. Most of the work has been done with x-rays for which image intensification has reduced exposure time to as little as 1 per cent of the time otherwise required.

The largest possible gain, namely the observation of a single quantum, can be obtained when the discharge medium acts as a spark counter. For such visual observation the photographic or luminescent layer is removed and one electrode is replaced by a glass plate covered with a transparent conductive layer to form an electropane. If the operating conditions are properly adjusted and if a radioactive preparation is brought in the vicinity of the chamber, one can observe sparks where ionizing radiation quanta enter the counter. When radiation from an x-ray source enters the counter, a great many sparks can be observed. If an absorbing object is then brought into the x-ray beam, sparks will disappear in the shadow, and the outlines of the object can be seen.



Arrangement of elements for detecting and enhancing radiation in a two-dimensional image.

Recently work has been initiated to extend the sensitivity of the counter to the longer wavelengths of the infrared region. In this portion of the spectrum, the incident radiation does not possess sufficient energy to produce electron emission. However, by inserting a photo-conductive layer (such as selenium) into the counter, it has been possible to control the operation of the counter with red and infrared light.

A large number of applications are envisioned in the field of biology and medicine. It may be possible to diagnose the location of tumors in which radioactive material has been concentrated, by pinhole camera techniques. Screen intensification and photographic intensification in radiographic diagnostic work may enable us to use only a small fraction of the radiation hitherto required and so to eliminate the danger of overdoses of x-rays. Light intensification may be of considerable importance in the improvement of astronomical photography and spectroscopy. Finally it may be possible to use the method for the intensification of x-ray fluorescent screens, television screens, and projection surfaces.

Crystal Filter Design

A PIEZOELECTRIC resonator is one in which an applied electrical stress gives rise to a proportional mechanical stress, and vice-versa. The existence of the piezoelectric effect in quartz and other materials was discovered by Pierre and Jacques Curie in 1880. The first practical application of the piezoelectric effect was a sonic depth finder originally devised by Paul Langevin of France at the end of World War I, as a means of detecting submarines.

At about the same time, A. M. Nicholson, working with piezoelectric Rochelle salt, and Walter G. Cady, working with quartz, showed that these materials could be successfully employed in oscillator circuits. The subsequent development of low temperature-coefficient quartz resonators made possible the stable piezoelectric crystal oscillator.

In 1922, Cady proposed the use of a crystal as a frequency selective element by taking advantage of the sharp maximum in current through the crystal

(Continued on page 110)

The Institute's Industrial Liaison Program

By EUGENE B. SKOLNIKOFF

LAST year some 68 corporations were invited to send representatives to 14 special technical symposia held especially for their benefit. Approximately 600 people came to M.I.T. for these meetings; the attendance figures promise to be even higher for the 1955 series of conferences. These special symposia are offered as part of the service provided for the companies participating in M.I.T.'s Industrial Liaison Program – a new and important plan for industry-university co-operation.

The idea for some sort of co-operation between M.I.T. and industry grew out of the financial problems encountered by the Institute following World War II, and resulted in the formation of the Industrial Liaison Program. Established in 1948, it was designed to help meet these financial needs, and, at the same time, to provide close technical contact between M.I.T. and industrial research. Now in its sixth year, the Program has come to have great significance as a medium for the exchange of ideas and the stimulation of progress in research, in addition to the considerable financial support it has brought M.I.T.

Industry has become increasingly aware in recent years of the financial difficulties of the independent universities, and a general acceptance of what industry's role in the matter should be has been evolving gradually. For example, in 1951 the National Association of Manufacturers adopted a resolution which declared that "Business enterprises must find a way to support the whole educational program – effectively, regularly and now." Alfred P. Sloan, Jr., '95, in an article in *Fortune* entitled "Big Business Must Help Our Colleges," commented: "It is vital – if we are to perpetuate our free society – that we find a way to keep our colleges, universities and technological institutions virile, progressive and – above all else – free. To stay that way they must have adequate financial support."

M.I.T. is in a fortunate position to attract industrial support, for the depth and scope of its research activities can provide something in return to industrial firms, over and above the education of engineers and scientists. The symposia already cited, special visits to the Institute, publications, all can be of material help to an industrial research program. In essence, what M.I.T. can offer is convenience of access to Institute laboratories and research programs as a "return" for industrial support.

This idea is the basis for the Industrial Liaison Program, which now has over 70 corporation members on a regular contractual basis. Most of the participating companies are among the nation's largest corporations, and most have indicated that this will be long-term support. Financially, the Program now accounts for approximately 10 per cent of the academic budget, but its over-all importance to M.I.T.'s educational and research program now extends much farther than the income alone.

Financial Background

At the time of inception of the Program, relatively new problems were besetting universities in the United States, and technological institutions particularly. Following World War II, enormous increases in enrollment were the first and most obvious changes that taxed the existing facilities. These increases affected the technological schools particularly because of the larger and more complex physical plant required to educate students in engineering and modern science. With adequate financial resources this problem could have been met, but two other conditions prevailed that made the situation serious.

The first was the inflation that essentially cut the real endowment income in half. The second was the gradual disappearance from the American scene of the large personal fortunes that had in the past provided a major part of the funds for our private universities. It was obvious then that the problem of increasing the endowment would be a difficult one and that perhaps it could never be solved.

Concurrently, various other problems came to the fore. Many institutions undertook large research programs for the government during the war and subsequently found that this government-sponsored research was continuing and, in fact, expanding in the postwar years. The principle of research as a necessary complement to a university's academic program is a sound one, but sizable financial considerations from any single source are always a matter of some concern to an independent institution. It is important, therefore, that schools like M.I.T. have sufficient financial reserves so that government funds never become essential to their operations. Technological institutions have another, continuing, requirement that devolves on them by virtue of their type of education and research. Close contact for the staff with industrial research and industrial man-power needs is essential to help guide the work in both the laboratory and classroom.

M.I.T. Photo

One means by which companies are kept informed of research progress is through visits to the Institute by representatives of the companies. Shown above is John Wulff, Professor of Metallurgy (with pipe), explaining a problem in metallurgy to visitors in the Sloan Metals Processing Laboratory.

Formulation of the Industrial Liaison Program

Recognizing all these requirements, M.I.T. turned to the one type of institution in this country that could help with each: the industrial corporation. Financially, industry remained the largest private source of wealth and, more important, industry was already beginning to recognize that it has a social obligation and an obligation to itself, to support private education. From the educational point of view, M.I.T. desired and needed more contacts with industry. Thus, the financial objectives complemented those of education. The problem remained of how to attract industrial support to satisfy these objectives and how to put the support on a semipermanent basis. For this part of the problem M.I.T., as noted before, is in a position to offer something concrete to industrial concerns.

The plan was then formulated: in return for long-term *unrestricted* financial support from a company, M.I.T. would pledge to keep the company informed of the research under way at the Institute and would make it possible for the company to keep in close touch with progress by visiting the staff engaged in the work. The unrestricted nature of the financial support is important here, for the financial needs fall in many different areas, and unless this income can be used freely, its value is considerably diminished. Thus, a plan was conceived that answered many needs at once: it added to income, helped maintain independence, and provided a clear channel for discussion and exchange on the laboratory level between industrial and Institute personnel.

This plan became the Industrial Liaison Program, and in 1948 active solicitation began to recruit members for it. In most cases, the companies were asked to sign or pledge membership for a five-year period to insure the long-term nature of the support. This became the normal pattern, and one of the more conclusive evidences of the success of the Program is the recent renewal of most of those original memberships for a second five-year period.

Operation of the Program

The actual mechanics of operation of the Program are carried out by the Industrial Liaison Office, with five staff members. The over-all objective of the Program is to provide the companies with what might be termed "convenience of access" to M.I.T., and to provide channels of communication between the company and M.I.T. staffs. To do this effectively, the relations with each of the participating companies must be highly personalized and informal; the operation of the Liaison Office is guided by those goals. Each of the staff members has the responsibility of handling the relations with a specific list of companies, and it is his job to learn about both M.I.T. and the companies intimately. In this regard, it might be noted that the personnel chosen to man the Liaison Office are usually highly competent young technical men who have demonstrated breadth of interest and who have the requisite personality characteristics. The staff normally considers the appointment as a steppingstone to other jobs after a period of a few years.

The concrete part of the "return" being offered the participating companies falls into three main categories: visits, symposia, and publications. In addition to regular activities of the Liaison Office, there are many special services that are tailored to the needs of the individual companies.

The first of the regular means by which the companies are kept informed of research progress is through the medium of visits to M.I.T. by representatives of the companies. These visits, treated on an individual basis, are for the purpose of giving designated company personnel, who are cognizant of broad areas of company research, a chance to "look over the shoulder" of those actually engaged in the work, to learn in greater detail what is going on, to discuss face-to-face their own activities and interests as it applies to M.I.T.'s work and, perhaps, to get a "technical steer" in a field related, but outside the scope, of their company's normal research program. These visits are an important part of the "two-way street" goal of the Program, for they give the M.I.T. staff a picture of industry's needs and provide a direct channel for the staff to keep abreast of the latest industrial developments in their own field. It sometimes happens that this type of contact has resulted in changes of emphasis in the work under way at the Institute when the Faculty is made aware of the research needs of industry. This, of course, applies to engineering research more than it does to science, and may be particularly true in the management and social science research areas at M.I.T.

To perform this part of the Program adequately, it is essential that the Liaison Office staff be familiar with all of the research programs of the Institute and

with the professional interests of the Faculty members. To aid in this and to provide a ready reference for company personnel, a directory of Institute research is published each year by the Liaison Office. Excluding all classified research, the Directory for 1954–1955 contains over 600 separate projects – a large order for any one person to know well, but nevertheless a spectrum of research that is bound to include subjects of interest to almost any industrial concern.

The second major category of the Liaison Program is symposia, which have come to be regarded by the companies as the most useful and significant of the activities. Each year, the Liaison Office sponsors approximately a dozen symposia exclusively for the participating companies; the subjects range over all of M.I.T.'s activities, but a conscious effort is made to match the interests of each of the companies several times each year. These conferences are designed to conform with the over-all purposes of the Program – that is, to provide more channels of communication between M.I.T. and industry and to give the companies a chance to "look over the shoulder" at work in progress. Thus, these meetings are very different from technical society meetings in which, normally, papers are presented only of completed work. Here are offered informal presentations of work in progress, meetings that provide ample opportunity for the give-and-take of discussion, and a chance for representatives of different technical disciplines to discuss the same subject. The membership of the Liaison Program consists of companies with varied interests, and the opportunities for their technical staff to mix with the technical staffs of other industries is unusual and rewarding. The Faculty, too, find these conferences highly stimulating, for they provide an unexcelled opportunity informally to sound out many different industries on their problems and to keep abreast of research developments all over the country. The topics for these meetings have included, for example, Fracture and Creep of Metals, Supervision of Research Personnel, Applications of Digital Computers, and Harmonic Analysis of Seismograms.

Systematic distribution of M.I.T. publications is the third of the regular services offered by the Program. The technical reports and progress reports of the M.I.T. laboratories are sent to the companies on a routine basis; preprints and reprints of staff articles for technical journals are sent as well. To give an idea of the scope of M.I.T.'s research activities, some 400 different reports were mailed from the Liaison Office in 1954 with a total of 60,000 items to all the companies. Naturally, each firm is not interested in all reports, but the companies are able to specify in advance in which fields they wish to receive publications.

The remainder of the services offered to participating companies all fall into a category that might be called "special" or "individual." The staff of the Liaison Office considers it part of its job to continually search for new ways to make M.I.T.'s facilities of use to the companies, within the framework of the normal ethics of operation. For example, where appropriate, a company might be invited to send a technical man to one of the M.I.T. laboratories for a period of several weeks or months to become thoroughly familiar with the practices in a particular field. Or, arrangements might be made for a Faculty member to visit a company and give a seminar or lecture on the company's home ground. If a company is interested in sponsoring a specific research project, or employing a consultant from the M.I.T. staff, contacts can be made with the most highly qualified personnel at the Institute available for the particular job in mind. These types of services and many others have been performed often during the existence of the Program, and to some companies these extra dividends have been of special value.

There is one other benefit to participating companies that arises almost incidentally from these activities, but a benefit that can be highly important when engineers and scientists are in such short supply. That is the contact with graduate students in the laboratory, rather than in a recruiting interview alone. There is a definite advantage for a company in establishing a technical relationship with a student while he is still working on his thesis, and such contacts can become significant when the student finishes his graduate work and is deciding where to accept employment.

Problems of Operation

The reasons for the creation of the Industrial Liaison Program and the actual operations of the Program have been discussed, but no mention has yet been made of the problems that occasionally arise and the means by which they are met. Perhaps the major problem that must be avoided arises from the basic difference in emphasis existing in industry and in the university. Specifically, many industrial firms must perforce be concerned primarily with short-range developments and projects and can devote but a small proportion of their attention to basic research. This situation does point up the advantages of a plan, such as the Liaison Program, for keeping abreast of the state of the art in fields somewhat outside the company's operations, but which may affect those operations. However, it also means that some industrial visitors will have specific immediate problems for which they need expert help. It is not the purpose of the Program to provide the answers for day-to-day problems; the Faculty at M.I.T. still retain their prerogative to establish private consulting relationships with industry. But where does the dividing line fall between a "state-of-the-art" visit and a "consulting" visit? In practice, this problem occurs rarely, but when it does there must be some criterion fair to all concerned. For operating purposes, a short visit with a staff member, not requiring any preparation on his part, is considered one of the services of the Program. When the staff member is asked to study a specific problem and must do some work on his own, then this is taken to be consulting. In general, when a question of making such a distinction arises, it is the function of the Liaison Office to see that the basis of approach by the company is an appropriate one. Of course, it frequently

happens that staff members make private consulting arrangements or receive support for specific research projects as a result of their brief contacts through the Liaison Program.

Other problems occur in the relations with the individual firms – problems of a completely different nature. Each company is unique, and that includes the level of activity of each. Too much activity might be troublesome, but so, also, is too little activity. M.I.T., as was pointed out before, is anxious to make the support long-term in nature, and this implies satisfied companies and genuinely friendly relations both ways. The Liaison Office, in this respect, is in the position of the retail store: the wares for sale can be laid out on display but the customer cannot be forced to buy. Successful operation of the Liaison Program assumes that the companies will take an active part by adequately disseminating the information within the company and by a willingness to send technical people on visits that may have only long-term results. In most cases, the company designates one man as Liaison Program representative, and frequently the success or failure of the relationship depends on his attitude and degree of enthusiasm. This may require individual attention in the form of visits by the M.I.T. Liaison officers or Faculty members to encourage greater participation. It is gratifying that only a small minority of the companies require any special treatment to bring about a higher level of activity.

In general, problems have arisen only rarely and it is fair to say that, in its six years of operation, the Liaison Program has become a truly integral part of M.I.T.

Future of the Program

The question of the future growth of the Program is a pertinent one, for it would seem offhand that the greater the number of companies participating, the greater the returns to M.I.T. However, the Program is now maintained as a quality operation, treating the participating companies on a highly individualized basis. It is necessary, therefore, to insure that any increases in number do not result in a retreat from individual, personal relations.

From a Program that started out primarily as a partial means of satisfying M.I.T.'s financial needs, the Liaison Program has become an essential part of the Institute's educational and research program. And not only has this occurred at M.I.T.; several other universities have started similar plans of their own. One cannot minimize the financial advantages, for obviously any arrangement that brings in over a million dollars a year of essentially unrestricted funds, without circumscribing any of the rules and mores by which the Institute operates, is desirable. At the present rate of return on endowment funds, the I.L.P. income is equivalent to about $25,000,000 of endowment.

But the Program is at least equally important as an aid to the Faculty, and particularly to the younger Faculty members. For them the Industrial Liaison Program provides a direct and continuing channel of information to and from some of the country's most forward-looking corporations. As a result, the Institute's educational program is enriched by these contacts, the students benefit in a very real sense, and, in a highly effective process of feedback, the M.I.T. research programs are stimulated through a realization of the possible application of the results of research.

In summary, perhaps it is sufficient to recall a statement once made by the Dean of Engineering: "If the Industrial Liaison Program did not exist, it would have to be invented . . . for the educational value alone." With such an attitude within M.I.T., the Industrial Liaison Program can be considered as having been graduated from experimental to permanent status – a sure sign of success.

M.I.T. Photo

Professor Gordon S. Brown, '31, Head of the Department of Electrical Engineering, takes an active part in one of the dozen or so symposia which the Industrial Liaison Office sponsors for its member companies.

Engineering Education And National Spirit

To Develop the Mind in Its Search for Excellence,

To Develop the Spirit in a Sense of Responsibility

Is the Challenge of Today's Engineering Education

By JULIUS A. STRATTON

The following article is the text of an address which was delivered by Dr. Stratton on May 7, 1955, on the occasion of the Centennial Celebration at New York University. In introductory remarks prefacing his address, Dr. Stratton said: "As we celebrate this Centennial, we are in a wider sense observing the progress in 100 years of the engineer from artisan to member of an esteemed profession in our society."

In every age the patterns of education have reflected the temper of the times and the culture and character of a people. To some future historians the rise and development of engineering education will reveal those great currents of thought and striving that have dominated the Nineteenth and Twentieth Centuries: the material triumphs, the philosophic conflicts, and the brooding spiritual doubts. It would be difficult to find a more fitting example of the evolving interplay between a society and its institutions. In the beginning the crude needs of freshly industrialized communities dictated the curricula; and now new learning, generated and disseminated by our schools of science and engineering, is remolding and transforming society.

Beginnings of Technical Institutions

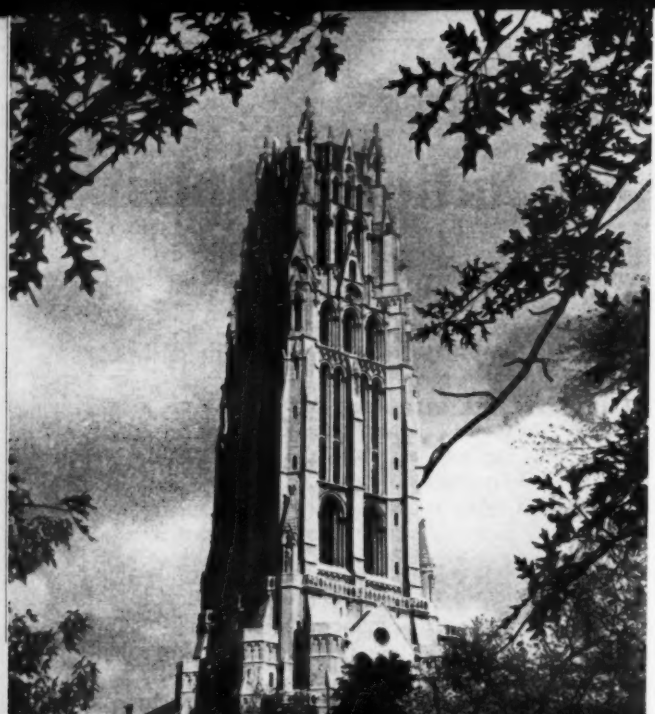
Let us glance back for a moment at the sources from which modern engineering education has developed, and trace briefly the stages through which it has passed.

The earliest roots reach back to the mechanics institutes which sprang up first in Britain and then in the United States toward the beginning of the Nineteenth Century. These were a direct product of the industrial movement of the times. For the most part they were voluntary associations of working people, formed spontaneously to help men keep pace with a changing and expanding technology. In no sense whatever were they professional schools, but dealt in practical matters and aimed at the encouragement and diffusion of scientific knowledge among mechanics, farmers, and artisans. Most of these institutes have long since disappeared, although a few still survive. They were significant of the awakening demand for popular education at the practical level, and they left their mark upon the curricula of our schools of engineering long after they themselves had vanished from the scene.

Neither the practical courses of these mechanics institutes, nor the classical curricula of Harvard or Yale or Princeton, could long meet the needs of men who were to grapple with the countless problems of emerging industry which reach beyond the accumulated experience of mill and shop. The years before 1850 saw the spread of this industrialization at an ever accelerated pace. Canals were built, railroads pushed through the wilderness, factory towns sprang up over all the Northeast. At the root of all this, of course, lay the invention of the steam engine. It was the availability of mechanical power which transformed our world in the mid-Nineteenth Century, as nuclear power may well transform it in the Twentieth. Within a few short years the capacity of man to construct and to produce was multiplied a thousandfold. The volume and variety with which the human mind had had to deal increased enormously. The time had come for a new synthesis in higher education.

Our oldest engineering colleges were founded in response to that demand. The United States Military Academy at West Point taught military engineering from the time of its establishment in 1802. Norwich, in Vermont, founded in 1819, incorporated engineering in its early courses. Rensselaer Polytechnic Institute appears to have had, since 1824, a clear claim to be first among the schools of technology in our modern sense. Then followed courses in engineering at Union College in 1845, and quickly thereafter the Scientific Schools of Harvard and Yale, New York University, Michigan, with M.I.T., Columbia and Cornell following in the 1860's.

Now it is true that this upsurge of American industry was the critical factor that led to the establishment of these new schools in the mid-Nineteenth Century. However, that in itself does not explain their character, their aims, or the nature of their curricula. To understand the intellectual forces that breathed life into these institutions, one must take account of the bitter philosophical controversies that



Ward Allan Howe

Religion is fortifying its place as a factor in engineering education as evidenced by the emphasis today on studies in the humanities. Impressive Riverside Church in New York, beautiful in architectural design as well as in engineering construction, appears above.

raged in those years in the mid-Nineteenth Century in the Western World.

The intellectual life of the Nineteenth Century was split between those who were moved by the spirit of rationalism and empircism which stems from the Age of Enlightenment, and those who held stubbornly to the classical idealism. The British utilitarian school, itself a product of the industrial epoch, represented the cause of rationalism, and it led the attack by the common people on the entrenched aristocracy in education of the great universities. One must appreciate the powerful influence of Jeremy Bentham, Lord Brougham, John Stuart Mill, and in this country of Robert Owen and Fanny Wright, upon the founders of American colleges in the Nineteenth Century. The efforts of Bentham and others from about 1825 to establish the University of London represented a direct attack upon the ancient universities, and in England they were bitterly resisted. But the Charter which William the Fourth ultimately granted to University College in London set forth as its aim the promotion of useful knowledge for all classes and denominations without any distinction whatsoever. Almost in the same year instruction began in a university of this other great metropolis, New York, with the announcement that "the children of the artisan and the tradesman shall be as welcome as the children of the rich," and "young men may be trained to become merchants, farmers, manufacturers, architects or civil engineers."

Now the word "utilitarian" does injustice to the school it represents. For these pioneers in education, "utilitarian" was by no means merely synonymous with "practical." They did believe that there is a dignity and importance in the mastery of useful knowledge; that science and technology are legitimate foundations of higher education; and that the process of learning, whether in classroom or laboratory, must be enriched by that direct experience which gives life and meaning to knowledge.

One must concede that many who engage in this controversy showed less concern for the teaching of technology than a sense of rebellion against the traditional university curricula hemmed in by the four corners of Latin, Greek, Rhetoric, and Paley's *Evidences of Christianity*. As the century wore on, the greatest intellects of the age joined the fray. Thomas Arnold and Cardinal Newman spoke eloquently in behalf of the true usefulness of liberal education, and Thomas Huxley and Herbert Spencer expressed with surpassing force and conviction the importance of relating education to the problems of our time. When all was said and done, a Royal Commission had made only small changes in the curricula of Oxford and Cambridge, the Scottish universities continued to cultivate the empirical along with the traditional learning, while across the Atlantic, Harvard University was transformed beyond recognition in the hands of Eliot. Yale University remained blandly unperturbed by the fracas, and colleges of engineering all over the United States reaped the harvest.

There were influences other than British, but their importance is more difficult to assess. A hundred years ago L'Ecole Polytechnique was the most famous technical school on the Continent, and unquestionably the example of its high standards impressed the founders of many of our own institutions. German influence was more significant, particularly in the realm of graduate work and research, and probably our large universities today owe more to the German model than to the British. The reader may recall the direct role that German influence played in the founding of the University of Michigan, of Johns Hopkins University, and of the University of Chicago. And so, too, the rising technological institutes of the German states played their part in the formation of our engineering colleges. The engineering schools of such cities as Brunswick, Berlin, Munich, and Stuttgart preceded our own by some 30 years, and drew the attention of some of our most distinguished educators.

Examine the catalogue of any American engineering school today and you will find vestiges of all the elements that entered into the original synthesis of an engineering education. From the mechanics institutes we have inherited what remains of shop-

work, foundry, surveying, mechanical drawing. In the "utilitarian rebellion" against classical curricula we threw out Latin and Greek, but retained English, history, and modern languages as the bare essentials of a liberal education. From continental schools, presumably, we learned to insist upon thoroughness in mathematics, physics, and chemistry. As to the "professional subjects," they are truly an indigenous product of American institutions. Not so long ago these were courses in dynamo design, steam boilers or dam construction; now in their place we expect to find circuit theory, thermodynamics, or soil mechanics – a clear sign of the maturing responsibilities of an engineer.

The Meaning of Professional Education

In this brief outline we have seen the roots from which our engineering colleges have sprung. How now shall they grow? Who are the engineers? What is their function, their responsibility; for what place in our society shall we educate them?

One hundred years ago there were scarcely enough engineering graduates in all the country to exercise an appreciable influence upon our industrial growth. Thus in the years immediately following the Civil War the total enrollment in engineering at New York University reached 39, while the entering class at M.I.T. in the fall of 1865 was only 72. By contrast, in the year 1954, some 214,000 were pursuing graduate and undergraduate engineering studies in 218 institutions, of which 150 are accredited at the professional level. And that imposing number, we are told, is wholly inadequate to satisfy the urgent needs of ever-expanding industry.

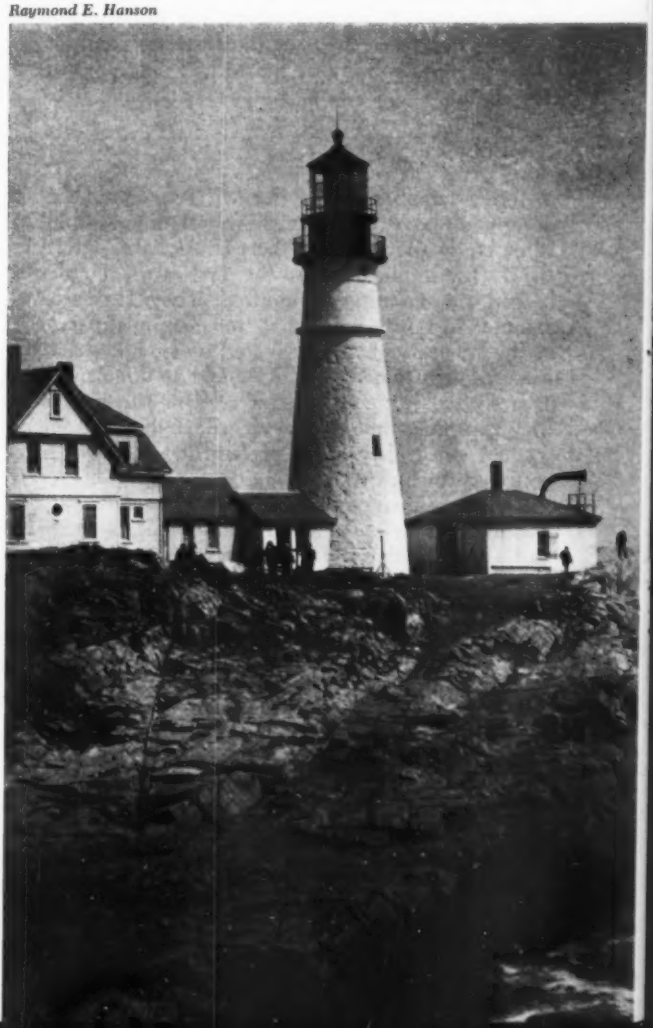
To ascertain the total number of men – and women – who in this country pass today for engineers would be well-nigh impossible. There are, for example, some 104 nationwide engineering and allied organizations in the United States with a listed membership in the neighborhood of 750,000. There are more than 2,500 local associations declaring engineering or technical aims with an untold membership. The so-called "Founder Societies" – the first great societies of the profession – are growing to impressive size. Thus the American Institute of Electrical Engineers has a membership of more than 46,000; the American Society of Mechanical Engineers exceeds 37,000; and the American Society of Civil Engineers has passed 34,000. And to these must be added the countless thousands who by lack of interest, or in default of the minimum technical qualifications fail to affiliate themselves with any professional organization. In all, they constitute a spectrum of human activity, shading by imperceptible degrees from the statesmen and leaders of the profession through management and design, through research and through operating practice, into production and sales, and on into the vast twilight zone of the technicians where many are engineers only by courtesy of self-given titles.

In a world that day by day witnesses the growing complexities of expanding technology, how are we to discriminate among all these people? Which are the engineers and which the technicians? The lawyers and the doctors have resolved this dilemma by the simple expedient of a definition: a lawyer is a man who has been admitted to the bar. The advantages of such a solution are manifest, and it is inevitable that a strong segment of engineering opinion should urge the extension of licensing procedure. Now it has become the practice to accredit our schools, and licensing seems in effect no more than the accrediting of an individual. Under the Engineering Council for Professional Development, the accrediting process has been wisely administered and clearly has contributed to the rising standards of engineering colleges. But for all the good that stems from the concept of accreditation, one may discern also the latent seeds of a national disease – the urge to conform and to impose conformity upon others. This is a symptom to which every engineer who has a concern for the future of his profession should be alert. Whether accreditation and licensing shall become forces for good or for evil rests with the engineers alone; it rests upon their wisdom, upon their capacity for statesmanship, upon their insight

(Continued on page 114)

Portland Head Light in Maine is a reminder of man's eternal struggle with the sea. New phases of engineering are helping to develop better ships, and recent studies in science indicate that the ocean can be more productive of sea foods, as well as a source of fresh water.

Raymond E. Hanson



The M.I.T. Coed—Then and Now

How Do Alumnae Evaluate Their M.I.T. Training? Do They Use It Professionally? What Do They Do after Graduation? Answers Are Provided by a Survey Recently Completed

By the REGISTRATION COMMITTEE, M.I.T. WOMEN'S ASSOCIATION

"She never held me on her knee
But she was all the world to me
. . . . . .
With Calculus she was well bred,
My Mother was a Tech coed."

THE 1954 Tech Show immortalizing the coed symbolizes an increased awareness of women students at Tech. Today's coeds are considered members of the M.I.T. community with equal responsibility in student government and campus activities. Coeds have been elected class officers several times in the past decade, as well as elected to head several student activities. The president of the Association of Women Students, the undergraduate group, now is a member of the Institute Committee – the governing body of the M.I.T. Undergraduate Association.

The First Coed

Active membership in the M.I.T. community, as described above, contrasts sharply with the situation Ellen H. Swallow (Mrs. Robert H. Richards) faced in 1871. Her application as the first woman student baffled the Faculty Committee. They had always assumed M.I.T. to be a school for men only. A search of the Institute charter revealed no such restriction. Rumor has it that by the expedient of admitting her as a special student, without fee, for the first term they kept her name off the record. If the experiment did not work, they could pretend it had never happened at the Institute.

The experiment worked so well, however, that she was awarded a bachelor of science degree in 1873, and a new laboratory for women was opened in 1876, made possible largely through her efforts and a contribution from the Boston Women's Education Association. The laboratory, providing instruction in "chemical analysis, industrial chemistry, mineralogy and natural history," proved a popular course in which over 100 women participated before it was discontinued in 1883. After this date, qualified women were admitted to any regular Institute course. By 1887 25 women were enrolled and by 1895 women constituted 6 per cent of the total enrollment. The percentage remained high until after 1900 when the majority of women's colleges began to offer courses leading to a science degree. For the last 40 years the figure has remained between 1 and 2 per cent.

The Average Tech Woman

A recent survey was made to determine what happens to M.I.T. women after they graduate. Do they use their technical education to make a contribution in their professional field and in the community in which they live? How many attempt both a career and marriage? A response from 72 per cent of the graduates and 30 per cent of the special students revealed that a Tech woman is a "woman for a' that."

The average Tech woman is a native of Massachusetts, is a scientist, is married to a scientist, has worked over 10 years in her field, belongs to professional societies, is active in community activities, and has a diversity of hobbies and outside interests. The fact that she is more likely now to return to active professional life after raising a family is in no small part a reflection of the changing status of women economically. A higher standard of living and an increasing acceptance of technically trained women in fields formerly open only to men are also contributing factors.

Although a Tech degree enables her to more than hold her own professionally, the average Tech woman, if we can judge from the Survey responses, feels the need of a broader education in the liberal arts. While the overwhelming majority were completely satisfied with their professional training, there was frequent mention, especially from those married to professional men, of the need for this broader liberal arts background in normal social contacts. The recent curriculum change allowing undergraduates to substitute courses in the humanities for professional electives recognizes this need. This should be of distinct advantage to the increasing number of undergraduates who are coming to Technology directly from secondary schools without advanced liberal arts training.

Courses Elected

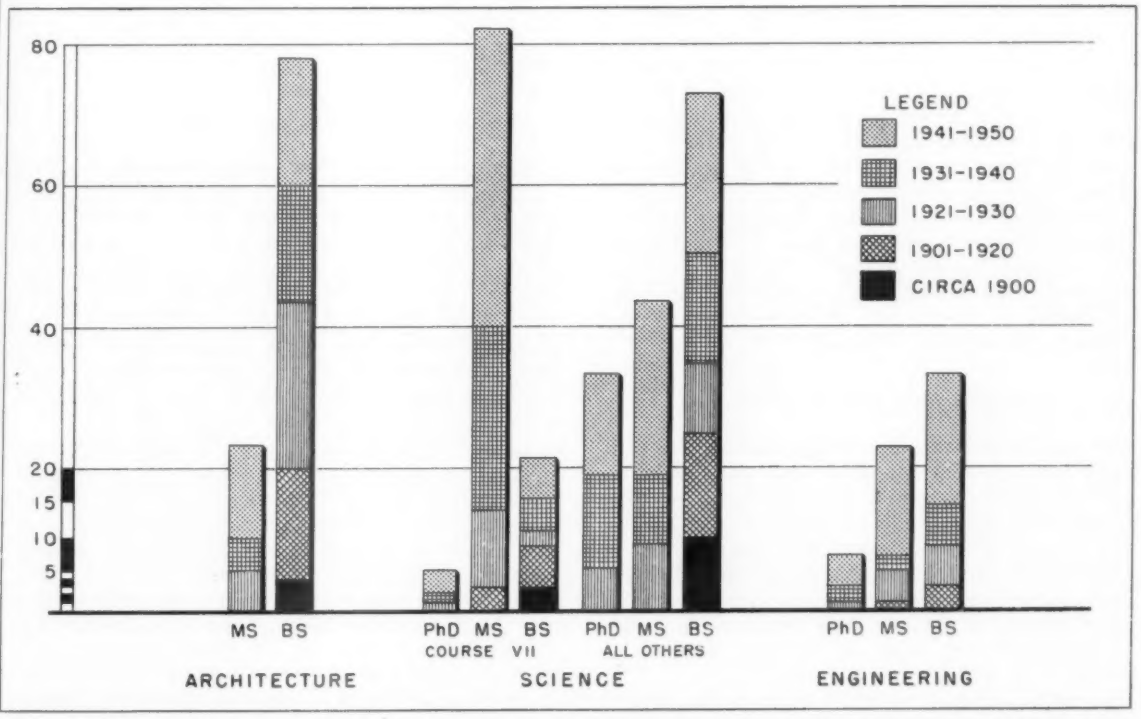
The diversity of courses which contemporary Tech women elect, as shown on the accompanying table, is perhaps the most outstanding single factor revealed by the Survey. Before 1900 Tech women elected only four courses: IV (Architecture); V (Chemistry); VII (Biology); and VIII (Physics). Between 1940 and 1950 degrees were awarded to women in all courses except III (Mining and Metallurgy); XI (Sanitary Engineering); XIII (Marine Engineering); and XIV (Electro-Chemical Engineering). In the 1940's alone degrees in Engineering were awarded to more

1953 SURVEY OF M.I.T. WOMEN

Course Majors By Class Groups And Degrees For All Living Graduates

Course No.	Name	Class Groups: -1900 D*	-1900 M	-1900 B	1901-1920 D	1901-1920 M	1901-1920 B	1921-1930 D	1921-1930 M	1921-1930 B	1931-1940 D	1931-1940 M	1931-1940 B	1941-1950 D	1941-1950 M	1941-1950 B	1951-1955 D	1951-1955 M	1951-1955 B	Total Number Degrees	Per Cent of Total Graduates
I	Civil Engineering	–	–	–	–	–	–	–	–	1	–	–	–	–	–	2	–	–	–	3	.6
II	Mechanical Engineering	–	–	–	–	–	–	–	–	–	–	–	–	1	1	–	–	3	–	5	1.0
III	Mining and Metallurgy	–	–	–	–	–	–	1	1	1	–	–	–	–	–	–	–	–	–	3	.6
IVA	Architecture	–	–	4	–	–	16	–	6	23	–	2	17	–	7	18	–	–	4	97	19.7
IVB	City Planning	–	–	–	–	–	–	–	–	–	–	2	1	–	6	1	–	1	–	11	2.2
V	Chemistry	–	–	8	–	–	10	3	5	6	8	2	7	8	9	13	3	1	6	89	18.1
VI	Electrical Engineering	–	–	–	–	1	–	–	1	1	–	–	1	–	3	3	–	1	2	13	2.6
VII	Biology, Public Health	–	–	3	–	3	6	1	11	2	1	26	4	3	42	6	2	4	1	115	23.4
VIII	Physics	–	–	2	–	–	2	2	3	2	2	3	3	4	7	4	2	2	6	44	9.0
IXA	General Science	–	–	–	–	–	2	–	–	2	–	–	4	–	–	2	–	–	4	14	2.8
IXB	General Engineering	–	–	–	–	–	1	–	–	–	–	–	1	–	–	4	–	–	4	10	2.0
X	Chemical Engineering	–	–	–	–	–	1	–	2	2	2	–	–	–	1	3	–	–	3	14	2.8
XII	Geology	–	–	–	–	–	1	–	1	–	2	2	–	–	3	–	–	–	1	10	2.0
XIII	Naval Architecture	–	–	–	–	–	1	–	–	–	–	–	1	–	–	–	–	–	–	2	.4
XIV	(See below)	–	–	–	–	–	1†	–	–	1†	–	–	–	–	–	–	–	–	2‡	4	.8
XV	Business Administration	–	–	–	–	–	–	–	–	–	–	–	1	–	–	2	–	–	4	7	1.4
XVI	Aeronautical Engineering	–	–	–	–	–	–	–	–	–	–	2	3	–	3	5	–	1	–	14	2.8
XVII	Building Construction	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	2	.4
XVIII	Mathematics	–	–	–	–	–	–	1	–	–	1	3	2	3	5	3	1	2	3	24	4.9
XIX	Meteorology	–	–	–	–	–	–	–	–	–	–	–	–	4	3	–	–	–	1	8	1.6
XX	Food Technology	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	2	4	.8
	None Specified	–	–	–	–	–	–	–	2	–	–	–	–	–	–	1	–	–	–	3	.6

*D indicates PhD. and D.Sc.; M indicates M.S., M.Arch., M.C.P., M.P.H., C.P.H.; B indicates B.S., B.Arch.
†Electro-Chemical Engineering
‡Course XIV is now Economics



The statistical information given in the table and chart is taken from a "Survey of Former Women Students at M.I.T." In May, 1953, questionnaires were sent to 1,357 former students; a total of 536 replies were received from Alumnae in 35 states and seven foreign countries, representing 72 per cent of the graduates and 30 per cent of the special or non-degree students.

women than in all previous years combined, evidencing the wider opportunities for women in these fields inspired by World War II and subsequent developments in nuclear physics and electronics.

Approximately two-thirds of all graduates were enrolled in the School of Science and almost a fourth in Architecture and Planning, with the remainder in the School of Engineering. A breakdown by courses shows that 23 per cent elected Biology. This reflects enrollment in the very popular course in Public Health which was offered at the Institute for some years prior to 1945. Twenty-two per cent studied Architecture and Planning, 18 per cent Chemistry, 9 per cent Physics, and 5 per cent Mathematics. The remaining 23 per cent were scattered among all courses except Sanitary Engineering.

Graduate Degrees on Increase

The 305 graduates responding to the Survey received 315 degrees, equally divided between undergraduate and advanced degrees. Three-quarters of the latter were master's and one-fourth doctor's. There is a noticeable increase in the number of graduate degrees since 1930, reflecting the trend toward graduate research in science and engineering.

93 Per Cent Employed after Graduation

Prior to World War I a college education could be afforded only by the well to do, and employment in scientific fields was not generally open to women. The war changed all this and opportunities opened up for women with technical training. On the basis of Survey findings, 93 per cent of all Tech women were employed after graduation, the majority of them working for over 10 years in their specialized field. As might be expected, a greater percentage of special students than graduates have worked in non-technical fields. Many have worked continuously since they left the Institute. Others worked for a short time before raising a family, and are now re-employed in their professional field.

One-third of the graduates reporting have contributed to the literature in their field and better than one-half belong to one or more professional societies. One-fourth of the special students have contributed to professional literature, and one-third belong to professional societies.

Tech Men Rate High as Husbands

By far the greater number of Alumnae have combined marriage with a career. Seventy per cent of the graduates have married and 40 per cent of these married Tech men. Analyzed by 10-year groups the per cent of graduates who have married has increased from about 50 per cent in the early 1900's to about 80 per cent in the last two decades. Professional men rated high in their choice of husbands, with half marrying technical men and another quarter marrying doctors, lawyers, or teachers.

Several graduates can boast of four, five, and six children, although the total 383 reported on the Survey for all graduates through the Class of 1950 indicates only 1.23 children per graduate.

Wide Scope of Activity

M.I.T. women are using their education in practically every field – military and government service; medicine, law, business; pure and applied research in education and industry; teaching at all levels; the arts; homemaking; and civic and community activities where her services are needed.

A number of M.I.T. women have passed their training on to succeeding students as professors in colleges all over the world. Many took premedical courses at the Institute and are now practicing physicians and/or professors at well-known medical schools. Several have combined engineering with law as patent attorneys, while others have used their training as background for writing, primary and secondary school teaching, and museum work. Tech women serve as consultants in such unfeminine fields as chemical engineering, heat transfer, and oil geology. The military forces report Tech women with such titles as Construction Management Engineer, Head of – Structural Engineering Branch – Design Division – District Office.

Why Did She Come to Tech?

Over half of the graduates reported their reason for coming to Tech as the reputation of the Institute for scientific education, or that of a particular professor or course. Some came many miles to find a technical school which would admit women. Many others took advantage of scientific education within easy commuting distance of their homes. To about 10 per cent the offer of an Institute scholarship or a grant for special study was a determining factor. Alumni relatives (excluding husbands) reported by 33 per cent may have had some influence on their choice.

Would She Do It Again?

From the point of view of the Alumnae, the 1871 "experiment" in coeducation has apparently been highly successful – 87 per cent of the women graduates would choose Tech again. Only the Ivy League figure of 98 per cent, according to a recent college survey, tops this. The same national survey shows that 75 per cent of the Alumni interviewed would choose the same field again, whereas 80 per cent of the Tech women are happy with their choice. These are interesting figures, especially since M.I.T. makes no special concession to its women students.

In the last 84 years science and technology have opened up vast new fields of knowledge which have substantially altered our manner of living. Increased opportunities in professional fields, a recognition of the potential contribution of technically trained women, in addition to release from household chores have been largely responsible for the difference in the position of the Tech woman of yesterday and today. Ellen Swallow was an oddity, to be tolerated by some and marveled at by others. Today's Tech coed is an accepted member of the college group, and after graduation becomes a valuable contributing member of her profession and citizen of her community.

When Smallpox Flourished in America

Brought to the Western Hemisphere by Spanish Explorers, Smallpox Caused Numerous Serious Epidemics but Is Now Almost a Forgotten Disease

By JAMES A. TOBEY

SMALLPOX, one of the most lethal and most dreaded of all diseases, virtually has vanished from the American scene. In 1953 there were only four cases of smallpox in the entire United States and in 1954 there were none, whereas 10 years earlier there were more than 400. Not so many years ago cases of this loathsome and deadly malady were numbered in the hundreds of thousands in this country, and there was a time when this scourge took off more than half of the population.

The havoc once caused by smallpox is illustrated by the situation in Boston 200 years ago. In 1752, when one of the periodic and seemingly inevitable epidemics of smallpox broke out, the population of this town was 15,684. The disease had been so prevalent in the past, however, that almost exactly 6,000 of the inhabitants already had had it, and so were immune. Another 2,124 were inoculated as a preventive measure, and 1,843 fled from Boston to escape the noxious contagion. This left about 5,700 potential victims of the disease, of whom 5,545 actually contracted it, and 569, or about 10 per cent, died. Less than 200 persons were lucky enough to evade the pestilence.

Before the Spaniards came to the Americas at the end of the Fifteenth and the beginning of the Sixteenth Centuries, smallpox was unknown in the New World, although it had flourished in the Old World since the dawn of history. The first recorded epidemic of smallpox in the Americas occurred in the West Indies in 1507, shortly after the fourth voyage of Columbus (1502–1504). Undoubtedly it was imported by a member of the crew from Europe, where the disease is known to have been rampant since the Fifth Century, when it came out of the Far East. In 1520 this terrible plague was brought to Mexico by a Negro slave in the train of the Spanish commander, Narváez. It swept across the land of the Eagle and Serpent like an unquenchable fire, and is estimated to have killed about 3,500,000 of the highly susceptible Indians. Among the victims in this great disaster was Cuitlahua, brother and successor to the Emperor Montezuma. Ten years later a similar epidemic occurred in Peru, causing a frightful mortality.

Two years before the Pilgrims landed at Plymouth in 1620, a severe epidemic devastated the Indian population in North America. It is reported that the warriors in the Northeast were reduced by it from some 9,000 to a few hundreds, and that the Massachusetts tribe alone lost 2,700 out of 3,000 persons. The early historians thought that this was an epidemic of smallpox, but there is doubt as to the exact nature of the malady. Unquestionably, it was one of the fatal gifts of the white man's civilization, since the Indians had been in contact with these superior creatures for more than a decade. Since 1606 fishermen from England had been regularly using Monhegan Island, off the coast of Maine, as a base of operations, and explorers from the Virginia Colony, established at Jamestown in 1607, had visited and named the New England region.

The first great epidemic of smallpox among the English colonists in America broke out at Saugus, Mass., in 1631 and spread rapidly from Narragansett to Piscataqua and also westward into Connecticut. It annihilated entire villages of Indians and killed off many of the settlers. The colonists continued to come, however, since the situation was no better at home, where smallpox raged unchecked. Among the many victims of the disease in this period (1633) was Chickatabut, sachem of the Massachusetts tribe of Indians.

During the next century, smallpox came in waves to the Americas, with serious epidemics every few years. Nothing could be done about it, except to offer prayers and decree days of general fasting. The austere Puritans took some comfort from the fact that the disease so reduced the Indian population that it also diminished their capacity to make war upon the white usurpers who had often treated the Indians so treacherously. In 1663 there was a severe epidemic of smallpox among the Dutch in the New Netherlands, and in 1678 about 800 persons are said to have died of the disease in Boston and other parts of Massachusetts.

Not until 1721 did hope for the conquest of the omnipresent smallpox appear on the troubled horizon of the American colonists. In that year a Boston physician, Dr. William Douglass, handed to the Reverend Cotton Mather – the most influential and dominant of the local clergy – a treatise from the Royal Society in London describing a method of inoculating against smallpox. This paper already was four years old, but the Reverend Mather read it with enthusiasm, and decided to espouse the new method.

Inoculation had been introduced into England a few years earlier by Lady Mary Wortley Montagu, wife of the British ambassador to Turkey, who had observed the system in Constantinople. "An old woman comes," she wrote, "with a nutshell full of

the matter of the best sort of smallpox – and puts into a vein as much venom as can lie on the head of a needle, and binds up the wound with a hollow bit of shell." Inoculation of the skin in this way usually resulted in much milder cases than those contracted in the customary manner through the respiratory tract, but occasionally an inoculated person suffered a severe bout of the disease and even died of it. In that day and age the chance seemed worth taking, since the mortality from inoculation was about one-tenth of the natural infection.

Reverend Cotton Mather promptly wrote a fervid pamphlet about inoculation. He endeavored to arouse the interest and support of the local doctors, but with one notable exception they opposed him to a man. Most of the clergy were impressed, however, and lined up with Mather. The one physician who had faith in inoculation was Dr. Zabdiel Boylston, who on July 27, 1721, inoculated his own son and two of his Negro slaves – with successful results.

The resulting furor split Boston into two violently opposing camps. The Franklins, James and Benjamin, launched a bitter attack on Boylston in their newly established newspaper. The doctor was mobbed when he went out, and had to visit his patients secretly at night. A bomb was sent to Mather, with a scrawled note, "I will enoculate you with this, with a Pox to you," but fortunately it failed to explode. Mather, noted among other things as a witch burner, paid his respects to his detractors in vitriolic language, calling them "Ideots and Franticks," and mentioning "the cursed clamor of a people strangely and fiercely possessed by the Devil." The courageous clergyman practiced what he preached, and had his own son inoculated; he recovered without any ill effects.

The excitement continued for some time, but eventually other physicians came to the support of Boylston, and inoculation was vindicated. In due course, Boston named a street after Boylston, a street which later (1865) became the site of a famous institute devoted to engineering education (M.I.T.). Benjamin Franklin, who had moved to Philadelphia, also changed his tune. After losing a four-year old son from smallpox in 1736, he became a staunch advocate of inoculation.

In 1751 a young man of 19 named George Washington, accompanied his half-brother, Lawrence, to the Barbados in search of a more salubrious climate for the latter's consumptive condition. In the West Indies, George Washington was exposed to the prevalent smallpox and contracted it. Fortunately, he recovered, but displayed pock marks on his face the remainder of his life – stigmata which do not appear in the portraits painted by Gilbert Stuart and other famous artists. In later years George Washington prescribed inoculation for his troops, and also persuaded his wife to take it. Of four hospitals established in the early days of the American War for Independence, one was exclusively for smallpox.

The expedition against Quebec, so gallantly led by Benedict Arnold in 1775, was frustrated by smallpox and other diseases. Colonel Arnold, his reputation then proud and unsullied, set out from Cambridge on September 17 with 1,100 troops, proceeded to Newburyport, and up the Kennebec some 30 miles beyond Norridgewock. Then came 100 miles of incredible hardships through the savage wilderness. Nearly one-half of the force sickened or died of smallpox and dysentery, or succumbed to cold and hunger. When the weary, enfeebled troops arrived before Quebec in the middle of November, they were too exhausted to attack. Had they been able to do so, the surprise assault might well have been successful, and the history of this country might have been different. After General Montgomery joined Arnold and the attack was made in mid-December, the British had been able to fortify their positions strongly, and the attack was repulsed. Montgomery was killed,

(Continued on page 119)

Dave Lawlor

THE INSTITUTE GAZETTE

PREPARED IN COLLABORATION WITH THE TECHNOLOGY NEWS SERVICE

Presidential Adviser

MAJOR GENERAL JAMES MCCORMACK, JR., '37, U.S. Air Force (retired), former Director of Research and Development in Air Force Headquarters in Washington, has been named a special adviser to the president of M.I.T. A former Deputy Commander and Vice Commander of the Air Force Research and Development Command, General McCormack has recently served as the Director of Research and Development in the Office of the Deputy Chief of Staff (Development) in the Headquarters of the United States Air Force in Washington. Previously he had served on assignment from the Department of Defense as Director of Military Applications in the Atomic Energy Commission.

"General McCormack has a wide background in problems in which M.I.T. is directly concerned, or is very much interested," said James R. Killian, Jr., '26, President of M.I.T., in announcing the appointment. "His advice will be of great value in the fields of military operations research, in which the Institute is assisting the Department of Defense, and in administering the Institute's wide program of sponsored research."

A graduate of West Point in 1932, General McCormack subsequently studied as a Rhodes Scholar at Oxford University, where he received the degree of bachelor of arts in 1935. In 1937 he took the degree of master of science in Civil Engineering at M.I.T. General McCormack has served as an Engineer Officer in successive grades in the Army (1932–1941), general staff officer in the War Department (1942–1946), with the 12th Army Group in Europe (1944–1945), with the Atomic Energy Commission (1947–1951), in the Air Force Research and Development Command (1951–1954), and most recently in Headquarters, U.S. Air Force, Washington, D.C.

He has received the Distinguished Service Medal, Legion of Merit with Oak Leaf Cluster, Bronze Star Medal, Legion of Honor (French), Croix de Guerre with Palm, and the Order of the British Empire.

Treasurer's Report

IN reporting on the Institute's financial condition to the M.I.T. Corporation on October 3, Joseph J. Snyder, 2–44, Vice-president and Treasurer, stated that the Institute's operating budget for the year was balanced, all construction projects in progress were financed, and it was possible to make additions to the funds of the Institute as required under established financial policies.

Unrestricted funds were drawn on heavily to meet operating expenses and capital expenditures, but these funds were maintained at the minimum level considered prudent in the light of the scale of the Institute's operations. The importance of applying unrestricted resources for improving existing facilities and programs, as well as to financing new undertakings, has been given careful attention. The increase in endowment and tuition combined should keep pace with the increase in academic expenses composed largely of direct salaries and wages. Income from endowment will need to move ahead more rapidly than academic expenses if an increasing proportion of these expenses is to be funded. The tuition increase, effective in 1956-1957, and approved by the Corporation during the year, will provide long-term financing of scholarships and salary and wage increases granted recently but now being met temporarily by other means.

The principal items in the Institute's operations for the past two fiscal years are shown, with the net change, in the following table:

Operation	*1953-1954*	*1954-1955*	*Increase*
Academic operations	$13,693,000	$14,813,000	$1,120,000
Endowment funds	46,058,000	48,056,000	1,998,000
Total funds	68,011,000	73,833,000	5,822,000
Gifts and grants	4,642,000	6,650,000	2,008,000
Plant assets	34,417,000	36,086,000	1,669,000
Investments:			
Market value	85,648,000	109,344,000	23,696,000
Book value	63,084,000	71,831,000	8,747,000
Cost of sponsored research:			
Division of Industrial Coöperation	15,240,000	9,568,000	–5,672,000
Division of Defense Laboratories	17,248,000	27,708,000	10,460,000

The decrease in the direct expenses of the Division of Industrial Coöperation and the increase in those of the Division of Defense Laboratories, were primarily due to transfer of the Instrumentation Laboratory and other projects to the Division of Defense Laboratories.

Academic operations for the past two fiscal years are compared in the following table:

Revenues and Funds	*1953-1954*	*1954-1955*
Tuition and other income	$4,487,000	$4,673,000
Investment income	1,232,000	1,259,000
Gifts and other receipts	2,775,000	3,560,000
Contract allowances for indirect expenses	3,472,000	3,543,000
Auxiliary activities	1,727,000	1,778,000
Total	$13,693,000	$14,813,000
Expenses		
Academic	$6,157,000	$6,142,000
General and administrative	3,491,000	3,919,000
Plant operations	2,318,000	2,975,000
Auxiliary activities	1,727,000	1,777,000
Total	$13,693,000	$14,813,000

Grants and funds included in gifts and other receipts were drawn on more heavily than last year to meet academic expenses and increased plant operation expenses, leaving other sources of income available for the increase in general and administrative

expense. Academic salaries and wages were higher, but total academic expenses were little changed, because special nonrecurring expenses decreased from the preceding year. Improved employee benefits, higher development expenses, and increased salaries and wages accounted for most of the change in general and administration expenses. Building space changes, major construction alterations, and special maintenance work made up the large increase in plant operations expense.

The continuing growth of gifts to the Institute is reflected in the following table:

Designation	*1953-1954*	*1954-1955*
Endowment	$760,000	$611,000
Buildings	274,000	1,531,000
Current use — invested	726,000	1,893,000
Industrial Liaison support	1,225,000	817,000
Other funds for current use	1,657,000	1,523,000
Gifts of real estate	———	275,000
Total gifts	$4,642,000	$6,650,000

The greater gifts for building funds reflected the successful efforts to secure the funds for the Karl Taylor Compton Laboratories and the nuclear reactor, and the funds for current-use invested included the splendid achievement of the Alumni Fund for the Compton Memorial. Construction has been undertaken on the Compton Laboratories, and the financing of the structure has been assured through funds on hand, contributions pledged, and use of unrestricted funds. The new building will add 11 classrooms — bringing the total at the Institute to 147.

St. Louis Regional Conference

ANTICIPATING a favorable nod from the weather man for the date of Saturday, February 4, 1956, five administrative officers and Faculty members from the Institute are planning to speak at the regional conference which is to be held at the Missouri Athletic Club in St. Louis. The conference is sponsored by the Alumni Association and the M.I.T. Club of St. Louis. Under the general title of "Today's Research and Its Impact on Tomorrow," Alumni and guests attending the conference will hear messages from James R. Killian, Jr., '26, President of M.I.T., two of the Institute's deans, and two professors.

George R. Harrison, Dean of the School of Science, will speak on "Frontiers of Science" and E. P. Brooks, '17, Dean of the School of Industrial Management, will present his views on "Today's Plans for Tomorrow's Management." The topic to be discussed by John G. Trump, '33, Professor of Electrical Engineering, is "High Voltage Particles and Radiation in Medicine and Industry." Also included on the program is a talk on "Nuclear Reactors as a Tool for Industry and Education."

The success of the regional conferences held last year in Dallas and Cleveland augurs well for the gathering in St. Louis which will emphasize research conducted at the Institute and the effect of this research in the future.

Inquiries and reservations for this event on February 4 should be directed to: Robert J. Joyce, '28, 802 Chestnut Street, St. Louis 1, Mo.

SAGE Council

THE first meeting of the Alumni Council for the 1955-1956 season was held at the M.I.T. Faculty Club, 50 Memorial Drive, Cambridge, at 7:45 P.M. on Monday, October 31. At this 312th meeting of the Council, Dwight C. Arnold, '27, President of the Alumni Association for the current year, presided. Upon conclusion of the dinner, Mr. Arnold introduced James R. Killian, Jr., '26, President of M.I.T., as the first speaker of the evening.

In reporting on recent activities at the Institute, Dr. Killian announced the establishment of a fund from Henry Ford, 2d, to be used for making an annual "Atoms for Peace" award, as reported in the November, 1955, issue of The Review (page 35). Members of the committee administering the "Atoms for Peace" awards, under the chairmanship of President Killian, are: Detlev W. Bronk, Ralph J. Bunche, Arthur H. Compton, Mrs. Douglas Horton, Mervin J. Kelly, and Alan T. Waterman. Dr. Killian announced the bequest of $1,000,000 to the Institute by David F. du Pont, '56, whose untimely death came as he was about to enter his senior year at the Institute. The David du Pont bequest is to be used for athletic purposes, as reported in the November, 1955, issue of The Review (page 37).

President Killian also reported that the fall term registration of 5,648 students represents an 80 per cent increase in enrollment over that of a decade ago. As a result, the Institute finds itself confronted by a shortage of housing facilities for undergraduate and graduate students — single and married — despite its program of providing substantial increase in the number of residential units since the end of World War II. A committee, of which Edwin D. Ryer, '20, is chairman, is now studying possible solutions to the housing shortage which, if not corrected immediately, may be expected to become serious with the anticipated increase in college enrollment in the next few years.

On behalf of the Audit and Budget Committee, Mr. Ryer reported that the budget for the Alumni Association for the year 1955–1956 had been approved, that accounts for the Association for the past year had been audited, and that a copy of the Auditor's Report is on file in the Treasurer's Office. The Association's budget for the 1954–1955 fiscal year was $61,271, and total disbursements exceeded this figure by $1,986. For at least the third consecutive year, the Association's deficit has been converted to a profit, by taking advantage of sound business and editorial operations of The Review, which for more than a quarter of a century has shown an excess of income over expenses.

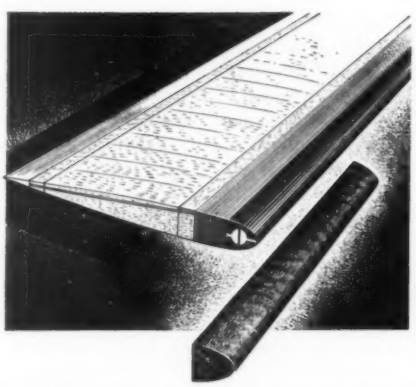
As Secretary of the Association, Donald P. Severance, '38, reported that changes in class affiliations for three Alumni had been approved. Between May 26 and October 31, visits had been made by 12 members of the staff to 18 M.I.T. clubs as far away as Mexico City, Los Angeles, Duluth, and Philadelphia. The Committee on Nominations for Departmental Visiting Committees was reported to have submitted four renominations and 17 new nominations for alumni membership on the Visiting Committees.

(*Continued on page 102*)

BUSINESS IN MOTION

To our Colleagues in American Business . . .

When close dimensional tolerances are required in an extruded shape, plus heightened tensile strength, and a fine finish, the shape is drawn through a die after extrusion. If there are special requirements as to straightness, the shape may also be straightened, as necessary, either by hand or by machine. These processes are expensive, but they produce a product that is accurately pre-formed, so that machining is markedly reduced, so much so as to effect remarkable savings. However, there is another way to take advantage of the economy of extruded shapes. Sometimes a "plain extruded" shape will do, thus saving the time and expense of drawing and straightening.



It all depends on what is really needed. Revere had an outstanding example of this recently. A rush order was received, and we could not meet the requested delivery date because of the time required to make new extrusion dies. On being told this, the purchasing agent visited our mill to see what could be done. A mutual study of the facts showed that the shape is to be applied to the leading edges of helicopter blades, and that both the shape and the wood are routed to make a close fit for the application of an adhesive. The shape is also tapered. Several things became evident. First, the original specifications were tighter than required. Second, shapes produced by the customer's original die, in our possession, would be slightly oversize, but not enough to be significant, in view of the subsequent machining. Third, by using that original die, and eliminating drawing, we could fill the order on time — and save the customer six cents a pound as well.

Now that we both knew that some of the dimensional and physical tolerances were not absolutely necessary, Revere was able to go ahead. The die was put in one of our extrusion presses, the metal forced through it, cut off to exact lengths, and shipped. This made it possible for the customer to complete his first blade on the day specified in his contract. We all worked fast, but no matter how quickly we labored, we could not possibly have met the essential delivery date on the basis of the original specifications. Close collaboration on what we call Quality Control provided the solution. Incidentally, brass was chosen for the part, because of its density, its resistance to corrosion, and the ease with which it can be machined.

Both our customer and ourselves are proud of the accomplishment reported here. It was made possible only by a thorough examination by both of us of the entire background of the order, the fabrication methods and end use, plus what the mill could do if it did not have to make new dies. We would like to suggest that when, as sometimes happens, a supplier cannot meet a date on a special order, you sit down with him and examine specifications to see if they really need to be so tight. You may find that a more or less run-of-the-mill product will do, thereby saving much time and money too.

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THE INSTITUTE GAZETTE

(*Continued from page 100*)

These nominations have the approval of the Executive Committee. Also reported by the Secretary was the official recognition, by the Executive Committee, of the newly established M.I.T. Club of Israel. It was also announced that Chenery Salmon, '26, chairman, had appointed C. Yardley Chittick, '22, William H. Carlisle, Jr., '28, Vincent T. Estabrook, '36, and John W. Sheetz, 3d, '42, to serve with him on the important Midwinter Meeting Committee. This meeting will be held in Walker Memorial on February 2, 1956.

Samuel C. Prescott, '94, chairman of the Committee on Resolutions, read a resolution on the late Arthur T. Chase, '86, formerly a member of the Alumni Council. The resolution was unanimously accepted by a silent rising vote.

Theodore T. Miller, '22, chairman of the Alumni Fund Board, reported that 11,176 Alumni had contributed to the Fund for the past year; this figure represents 1,500 more Alumni than had contributed for the previous year. Of the Alumni Council, 96.6 per cent of its members had contributed, whereas 34 per cent of the alumni body participated in last year's Fund. Total contributions to the Alumni Fund for the year 1954–1955 amounted to $551,485 from Alumni, $514,705 from an anonymous donor, and $150,000 which was withdrawn from accumulated resources of the Alumni Fund. Thus, the total contributions for which the 1955 Alumni Fund is responsible through alumni giving amounted to $1,215,000 – a most impressive record indeed.

For the coming year, Mr. Miller announced that the Alumni Fund has two specific objectives which it believes to be worthy of special support. One of these is support for general scholarship funds for M.I.T. students; the other is for funds for research and education in medical science.

President Arnold then introduced Edward L. Cochrane, '20, Vice-president for Industrial and Governmental Relations, who spoke briefly on the Institute's criteria for undertaking sponsored research for the government or industry. The five criteria which the Institute uses in accepting or continuing sponsored research projects are that: (1) M.I.T. has exceptionally qualified personnel, unusual experience, or special equipment for conducting the project, and one or more of its Faculty members are willing and able to assume responsibility for the project; (2) the project can remain unclassified and can be administered with a minimum interruption of the Institute's educational and basic research programs; (3) students may participate in the research as a part of their educational program; (4) the project does not involve the Institute in a major financial outlay; and (5) personnel and space can be made available for the proper conduct of the project. Compelling national interests sometimes require that the Institute undertake sponsored research when these criteria cannot be fulfilled or when the Institute derives no particular educational benefit from such work for either its students or its Faculty.

Project Lincoln, housed in government-provided facilities at the Bedford Airport, is an example of a multimillion-dollar project whose administration was undertaken several years ago when it became clear that the national interest required the Institute to take such action. For several years, Albert G. Hill, Professor of Physics, headed Lincoln Laboratory until he requested that he be allowed to return to academic work last summer. Marshall G. Holloway, who has had extensive scientific and administrative experience in government-sponsored classified research, has recently assumed direction of the Lincoln Laboratory, and Admiral Cochrane took obvious pleasure in introducing Dr. Holloway to members of the Alumni Council.

In his response to Admiral Cochrane's introduction, Dr. Holloway expressed his pleasure at being selected to head Lincoln Laboratory, and his further pleasure at being affiliated with the Institute in this new assignment. Dr. Holloway spoke of the very important and necessary job being done by the Lincoln Laboratory as part of the nation's defense preparations, and stated that the Semi-Automatic Ground Environment activities, shown in a motion picture as the final feature of the meeting, were but part of the contributions which Lincoln Laboratory was making to national security.

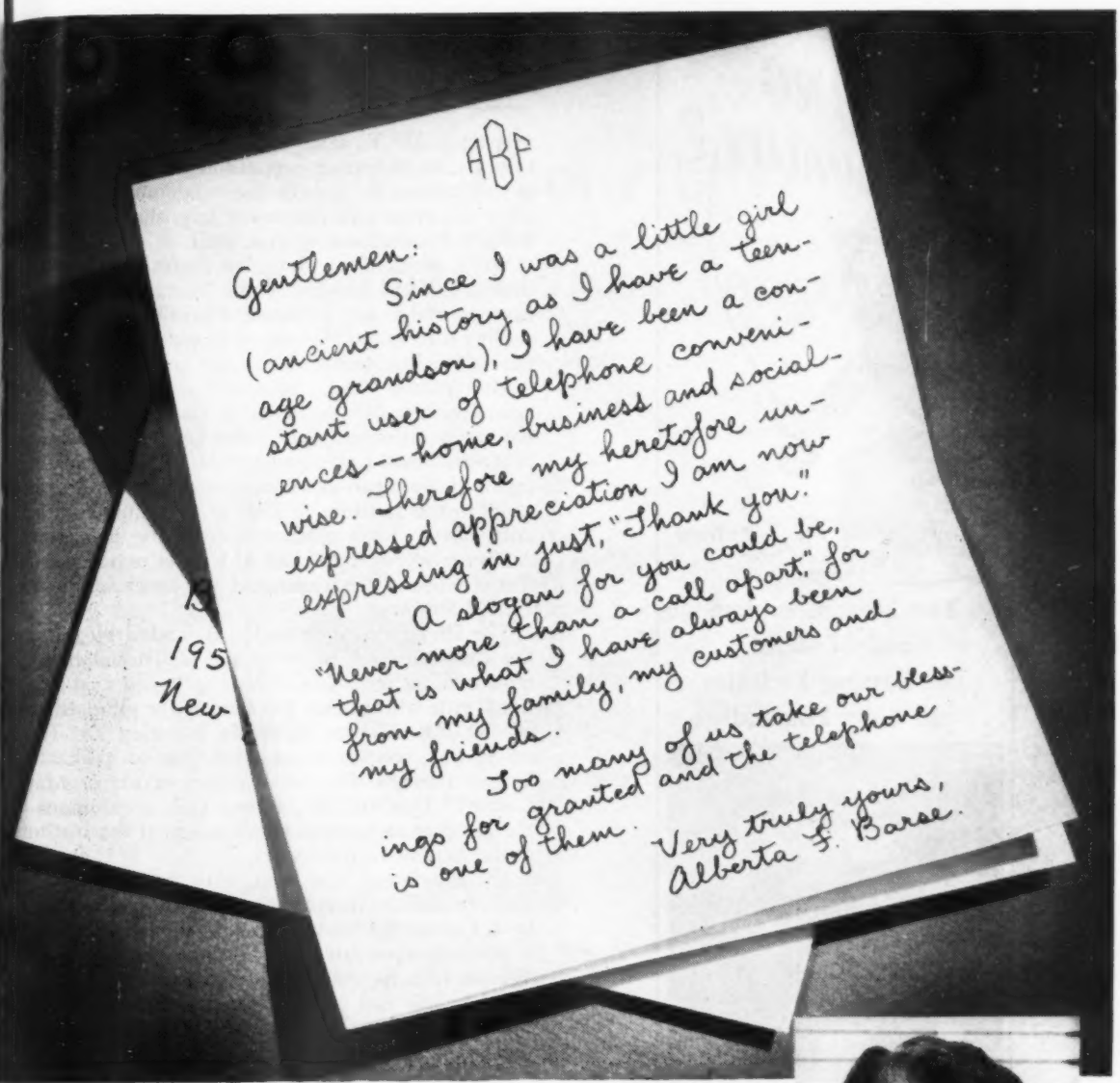
Final event on the program was the showing of a color film on the Semi-Automatic Ground Environment – abbreviated SAGE – system. This film portrayed the methods by which data from ground radar stations, Texas towers, picket ships, and early warning aircraft are fed to a large-capacity digital computer, such as the Whirlwind I computer developed at the Institute. Information relating to attacking enemy air-borne craft is obtained from radar systems and is fed to computers which carry out functions of identifying enemy aircraft, and plotting and predicting their courses. On the basis of such information, officers in charge of tactical operations may commit to action suitable defensive weapons, whose courses are also calculated by the computer. The SAGE system is able to direct defensive weapons to their targets with a minimum of human intervention. The meeting was adjourned at 9:15 P.M.

Hawthorne Now Hunsaker Professor

WILLIAM R. HAWTHORNE, '39, has been appointed to the distinguished new Faculty post of Jerome Clarke Hunsaker Professor of Aeronautical Engineering at the Institute for the current academic year, according to an announcement by James R. Killian, Jr., '26, President. Dr. Hawthorne is on leave from Cambridge University, England, where he holds the Hopkinson and Imperial Chemical Industries Professorship of Applied Thermodynamics. His principal interests are the fields of aircraft propulsion and advanced fluid mechanics; at M.I.T. Dr. Hawthorne will divide his teaching efforts in these fields between the Departments of Mechanical and Aeronautical Engineering.

Commenting on this appointment, C. Stark Draper, '26, Head of the Department of Aeronautical Engi-

(*Continued on page 104*)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Alberta F. Barse.

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Geo. Swift '24 Ed Beaupre '41

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(*Continued from page 102*)

neering at M.I.T., said: "The rapid pace of new developments in aircraft propulsion and aerodynamics is well known. Dr. Hawthorne's appointment emphasizes the great and increasing importance of these fields in the engineering of aircraft."

While at M.I.T. as Hunsaker Professor, Dr. Hawthorne will deliver the Minta Martin Aeronautical Lecture, which may be repeated in other aeronautical centers throughout the nation in order to emphasize the national character of this new professorship.

The Jerome Clarke Hunsaker Professorship was established in 1954 in honor of Professor Hunsaker, founder and for many years Head of the Department of Aeronautical Engineering at M.I.T. and a leading figure in American aviation. Professor Hunsaker first came to the Institute in 1909 as a graduate student after having been graduated from the U.S. Naval Academy at Annapolis. At M.I.T. he organized the first Course in Aeronautical Engineering in the United States.

The Hunsaker Professorship is funded by gifts to the Institute from industry and individual donors, now totaling over $360,000. It is hoped that additional gifts will increase the fund to the ultimate goal of $500,000. The professorship honoring Dr. Hunsaker was conceived and brought to realization largely through the initiative and efforts of Major Lester D. Gardner, '98, of New York, an alumnus of the Institute and one of the founders of the Institute of the Aeronautical Sciences.

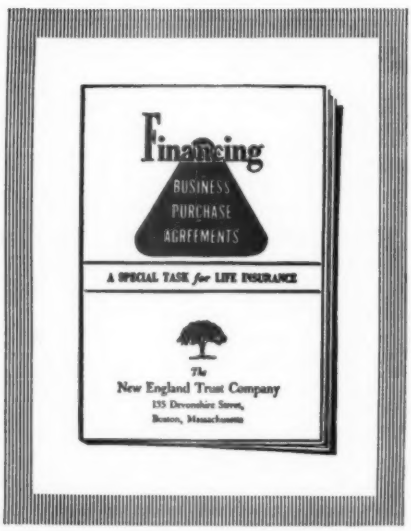
Dr. Hawthorne was born in Benton, England, in 1913. In 1934 he received the bachelor of arts degree from Cambridge University. After a year's service as a graduate apprentice with the firm of Babcock and Wilcox, Ltd., he came to M.I.T. as a Commonwealth Fund Fellow and completed work for his doctor of science degree in fuel engineering in 1939. Dr. Hawthorne then returned to England to join Babcock and Wilcox as a development engineer, working on combustion, heat transfer, and problems of steam generation.

From 1940 to 1944 he was scientific officer and head of the Gas Turbine Division at the Royal Aircraft Establishment in Farnborough, engaged in work on gas turbines and jet propulsion. During this period he worked on combustion chamber development with Sir Frank Whittle, who built the first jet engine. Professor Hawthorne came to this country with the British Air Commission in Washington in 1944 and later returned to England to become deputy director of engine research at the Ministry of Supply (Air) in London. He was awarded the U.S. Medal of Freedom in 1946 for his jet engine work.

In 1946 Dr. Hawthorne returned to M.I.T. to serve as Associate Professor of Mechanical Engineering and in the following year was appointed George Westinghouse Professor of Mechanical Engineering. He was the first to fill this chair and did so with distinction for three years, in association with the In-

(*Continued on page 106*)

What is your business worth to your family?



Sometimes a business has to be sold when the owner dies—there's no one in the family who is willing or able to carry it on.

If this is so in your case, have you made arrangements in your estate plans to have your business sold at a price that reflects its true worth?

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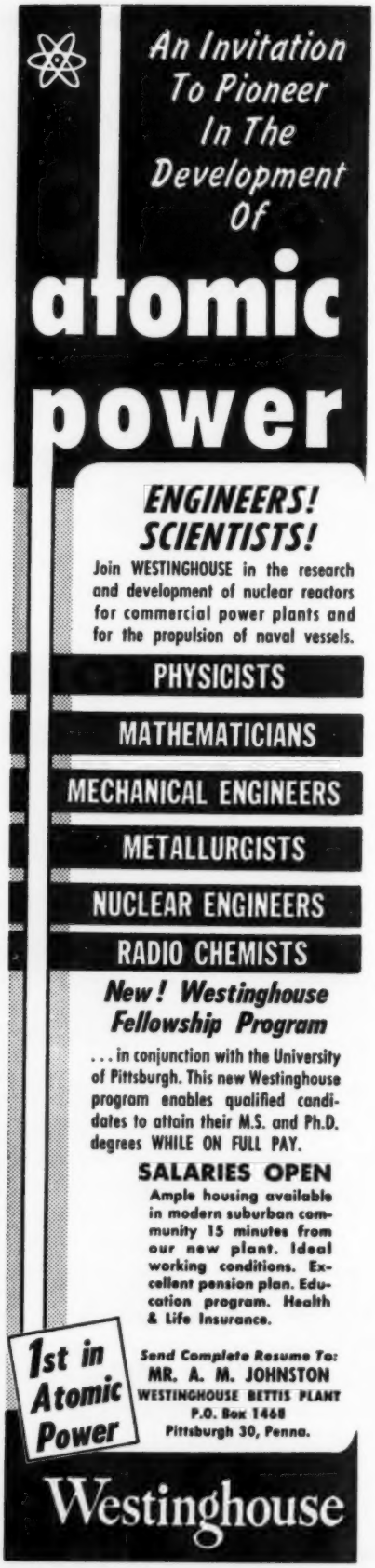
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THE INSTITUTE GAZETTE

(*Continued from page 104*)

stitute's Gas Turbine Laboratory. In 1951 he returned to Cambridge University to accept the newly created applied thermodynamics professorship at that institution.

Dr. Hawthorne is a Fellow of both the Royal Society and the Royal Aeronautical Society and of Trinity College, Cambridge. He is a member of the Institute of the Aeronautical Sciences and of the Institution of Mechanical Engineers and a Fellow of the American Academy of Arts and Sciences. He has served on many governmental committees both in this country and in England dealing with aircraft propulsion, fuels, and guided missiles.

Dr. Hunsaker, in whose honor this new professorship is named, was called to active duty with the U.S. Navy in 1916 to take charge of the Aircraft Division of the Bureau of Construction and Repair. He was graduated from M.I.T. in 1912 and remained at the Institute as instructor in aviation. In his post with the Aircraft Division, Professor Hunsaker supervised the design of the *NC-4*, the first aircraft to fly across the Atlantic. He was later in charge of the design of the airship *Shenandoah* while connected with the Goodyear Aircraft Corporation.

In 1934 he returned to M.I.T. as Head of the Mechanical Engineering Department. He retired as Head of the Department of Aeronautical Engineering in 1952 to become, as he is now, Professor Emeritus and Lecturer. Professor Hunsaker has received many honors. These include the Navy Cross (1919), the Daniel Guggenheim Medal (1933), the Franklin Medal (1942), the Presidential Medal for Merit (1946), the French Legion of Honor (1949), the Wright Brothers Memorial Trophy (1951), the Godfrey L. Cabot Trophy (1953), and the Langley Medal (1955).

New Solar House Planned

PLANS to build a full-scale, sun-heated house were announced by M.I.T. professors taking part in the World Symposium on Applied Solar Energy at Phoenix, Ariz., early in November. The house will be built in the Boston area this winter and is expected to be completed next spring. The M.I.T. interest is chiefly in testing solar heating and the house will be sold to a family who will live in it while data are gathered.

Since sunshine is undependable in New England during the winter, an auxiliary oil-heating plant will be needed, but solar energy is expected to supply from 80 to 90 per cent of the heat for the house and the oil bill for the year should not total more than $50. Solar energy will also supply an abundance of domestic hot water year around. An air-cooling system will operate during the summer. A great deal of the information used in designing the house was obtained from tests on a small house built in 1948 on the M.I.T. campus, facing Memorial Drive, and occupied today by a student and his family.

(*Concluded on page 108*)

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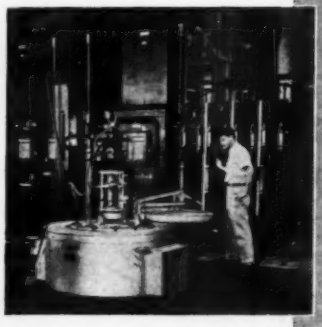

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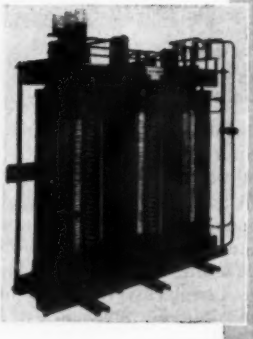

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THE INSTITUTE GAZETTE

(Concluded from page 106)

Solar heat will be received by a "collector" consisting of two layers of glass over copper sheet painted black. Heat will be transferred from the copper to water circulating in copper coils. The hot water, leaving the collector at a temperature of approximately 150 degrees, will be stored in a large tank. A heat exchanger and a fan will transfer the heat to air which will be carried throughout the house in ducts. The system will be controlled thermostatically so that when there is a succession of sunless days, the oil burner will start automatically.

Lawrence B. Anderson, '30, Professor of Architecture and chairman of the Committee on Space Heating with Solar Energy which has planned the house, said:

It is true that the cost of heating the house will be very low, but the initial cost of equipment will be too high to justify an installation by the average home builder in the near future. This is especially true of this first house, for which the collector will have to be handmade. Factory fabrication of collector parts would reduce costs.

But there is still the problem of providing enough capacity in the solar-heating system to take care of the stretches of cloudy weather. We could theoretically store enough solar heat for long periods of cloudy weather, but to store enough heat for even 10 days would require such an enormous storage system that it appears out of the question. Therefore we have added a conventional auxiliary heater as a lesser evil.

Solar heating is probably now economically feasible in areas where there is ample clear weather and where the cost of fossil fuels is abnormally high. We hope through further research to solve some of the problems that make it unfeasible for other conditions.

Professor Anderson was moderator for a discussion on "The Architectural Problem of Solar Collectors" at the conference in Phoenix. In another session, Hoyt C. Hottel, '24, Professor of Fuel Engineering at M.I.T., spoke on "Residential Uses of Solar Energy." Also speaking on the program was Austin Whillier, '53, who formerly was engineer-in-charge of the M.I.T. Solar House.

Lawrence J. Heidt, Associate Professor of Physical Chemistry at M.I.T., spoke at the symposium on "Converting Solar Energy to Chemical Energy," describing further studies of a method, first disclosed in 1953, by which water in certain solutions is converted into oxygen and hydrogen by light.

In addition to Professors Anderson and Hottel, members of the Committee on Space Heating with Solar Energy are: Albert G. H. Dietz, '32, Professor of Building Engineering; August L. Hesselschwerdt, Jr., '31, Associate Professor of Mechanical Engineering; and Joseph Kaye, '34, Professor of Mechanical Engineering. They have been assisted in planning the new solar house by Dr. Whillier; Richard W. Hamilton, '50, research associate in Architecture; Robert J. Pelletier, '51, research associate in Civil Engineering; and Bernard P. Spring, '51, instructor in Architecture.

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TREND OF AFFAIRS

(Continued from page 86)

at its resonant frequency. The combination of crystals, inductances, and capacitors in filter networks by Warren P. Mason made possible the many present-day applications of crystal filters.

Because of the very low dissipation inherent in the quartz resonator, it is possible to make filters with very high selectivity. Crystal filters are used in noise and sound analyzing devices which permit frequency spectra to be determined with very high resolution, in carrier systems for separating out control frequencies, and in radio communication systems for selecting harmonics of local oscillator signals. In addition, they have been applied to carrier telephone systems, where they permit the use of very small channel spacings; to single side-band systems for separating the two side bands; and to amplifiers where very high selectivity is desired.

Except for their use in carrier telephony, widespread application of crystal filters has been inhibited by lack of simple design techniques, and by lack of effective and inexpensive means for manufacturing crystals to the close tolerances required for filter applications.

A project which has recently been completed in the Institute's Research Laboratory of Electronics has been concerned with the development of new techniques for the synthesis and realization of filters employing piezoelectric resonators. As a result of this research, the availability of economical crystal filters to industry and research laboratories may be substantially increased.

The procedure developed permits very rapid solution of the crystal filter synthesis problem, with sufficient accuracy for determining whether or not the filter is realizable in terms of the properties attainable from a crystal resonator. The synthesis procedure is essentially based upon two types of approximations. The first approximation permits the attenuation, phase, and image impedance characteristic of a band-pass filter to be normalized with respect to bandwidth and center frequency. A single set of normalized characteristics is sufficient to describe all possible band-pass crystal filters with negligible practical error. A graphical method has been derived which

(Continued on page 112)

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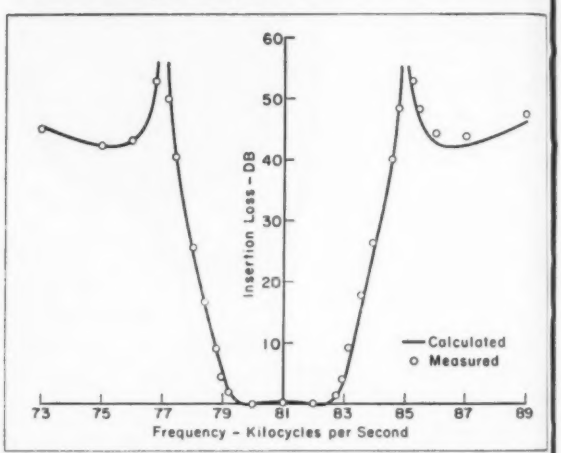
(*Continued from page 110*)

greatly simplifies the determination of the attenuation characteristic necessary to satisfy a given set of filter specifications. The analytical simplicity afforded by the normalization technique makes possible calculations of all filter losses, including the effects of incidental dissipation, with a minimum of effort.

The second approximation mentioned above is one which permits the element values of the reactances which are employed in a crystal filter, to be calculated in terms of the difference between the critical frequencies of the reactances. With the aid of this approximation and the normalization already described, the filter design may be accomplished very rapidly using only a slide rule and a number of simple plotted curves.

In addition to the synthesis methods described, a number of important techniques relating to the realization of crystal filters have been evolved. For example, analytical methods have been derived for determining restrictions on crystal filter band-widths and attenuation characteristics, without carrying through the corresponding synthesis. Moreover, the specification of tolerances on crystal units has been greatly simplified by a technique which permits the analytical determination of permissible variations of crystal parameters, in terms of the corresponding effect upon filter attenuation. Perhaps the most significant contribution to filter realization, in terms of the procurement of crystal resonators for filter applications, has been the development of a device which permits the crystal manufacturer to adjust the electrical parameters of the crystal unit to the required tolerances, without elaborate or specialized testing equipment.



Quartz crystal band-pass filter whose calculated performance is shown by solid line; circles indicate filter behavior as measured.

Because of the low dissipation and high stability of the crystal element, a very close agreement may be expected between the calculated and measured

(*Concluded on page 114*)

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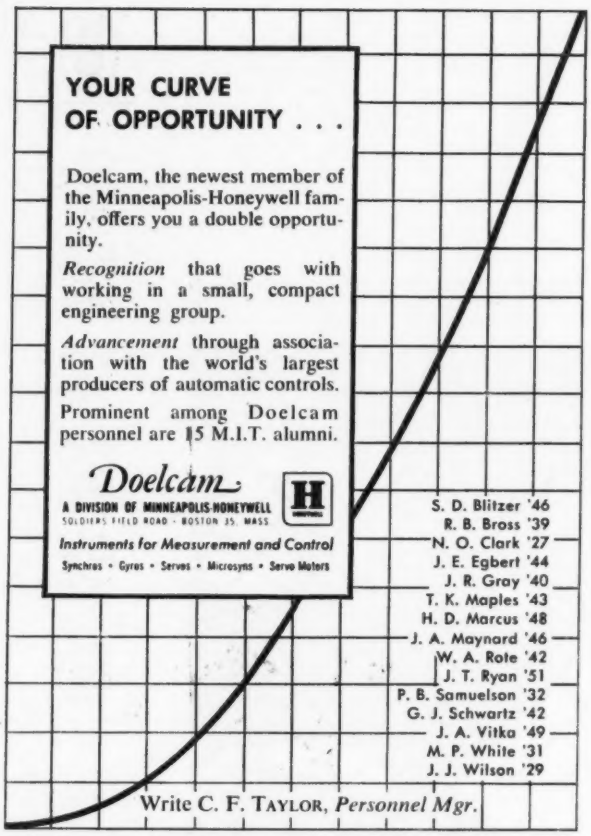
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TREND OF AFFAIRS

(Concluded from page 112)

characteristics of a crystal filter. To illustrate this agreement, the insertion loss of one of the band-pass crystal filters constructed at the Research Laboratory of Electronics is shown on page 112. The filter is realized in the form of a symmetrical lattice and employs two crystal units, two inductances, and several small ceramic capacitors.

A description of this research is contained in a doctoral thesis by David I. Kosowsky, '52, research assistant in the Department of Electrical Engineering, supervised by Henry J. Zimmermann, '42, Professor of Electrical Engineering. The encouragement and assistance received from Professors Jerome B. Wiesner, Ernst A. Guillemin, '24, and Samuel J. Mason, '47, all of the Department of Electrical Engineering, are also gratefully acknowledged.

The significant portions of the thesis have been published in a Technical Report of the Research Laboratory of Electronics. The work was sponsored in part by the Army Signal Corps, the Office of Naval Research, the Office of Scientific Research and Development, and the Air Research and Development Command.

ENGINEERING EDUCATION

(Continued from page 93)

into the nature of engineering as a profession. For this idea of engineering as a profession in the highest sense, and of the engineer as a professional man, should have stronger roots than the mere bond of school or occupation.

Medicine, I believe, is the art and science dealing with the prevention, cure, or alleviation of disease. Likewise, engineering has been defined as the art and science by which the properties of matter and the sources of power in nature are made useful to man in structures, machines, and manufactured goods. Deeper than all such definitions are the processes of thought, the attitudes of mind, the sets of values that distinguish the engineer from the doctor, the lawyer, or the physicist. The engineer must have developed an innate sense and feel for the physical

(Continued on page 116)

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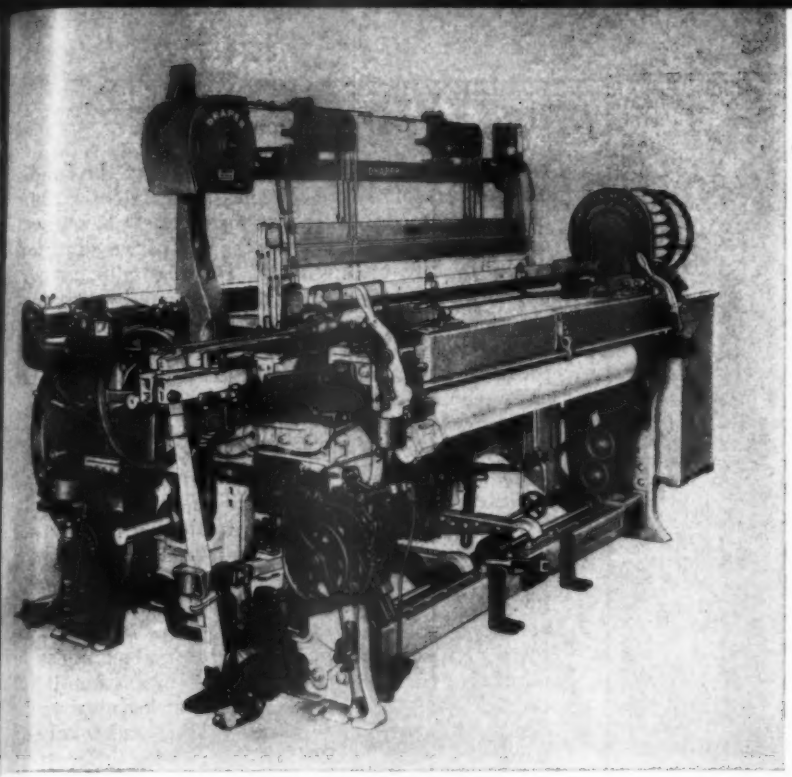

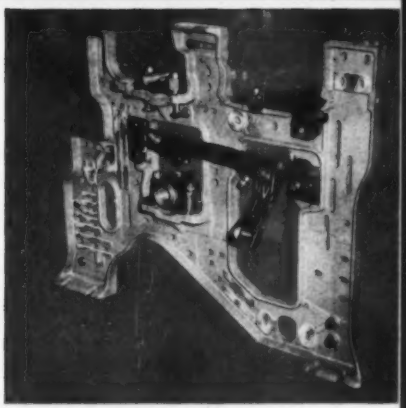

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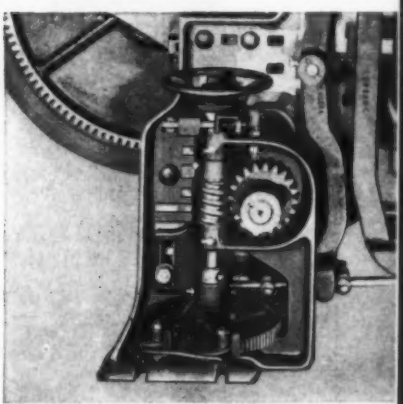

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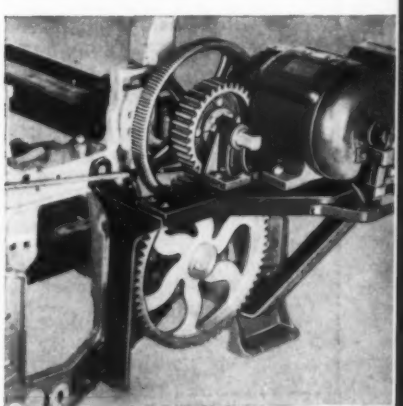

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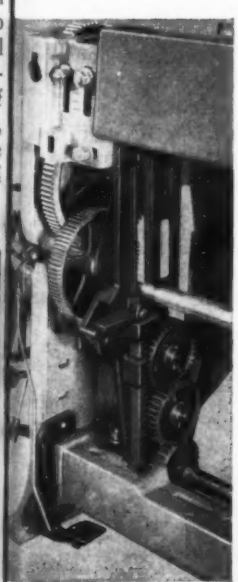

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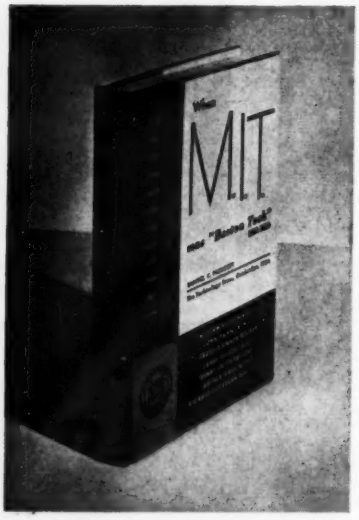

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ENGINEERING EDUCATION

(*Continued from page 114*)

properties of matter and the operation of the fundamental laws of nature. He has a capacity to think in concrete terms; he resorts instinctively to numerical estimates, and he accepts the role of the empirical in the making of judgments. His reasoning is governed by concepts relating to the strength of materials, of factors of safety, of weight and form, of friction and efficiency, of the manifold limitations of pressure, temperature and volume, of components and systems.

In greater or lesser measure, all engineers share these modes of thought and action – and so do the technicians. Only to the degree in which they have captured the professional spirit may we distinguish between them. It is a subtle, intangible quality not to be reduced to definition – an ideal toward which we aspire. The common denominator of all conceptions of professional status, whether of medicine, law, or engineering, is a high sense of personal responsibility to client and to society, with a readiness to minister to the public welfare. A profession is, of course, based in some special field of learning, to be dealt with at a high intellectual level and involving intricate techniques. We take for granted the mastery by a professional man of the principles that underlie his special field, and their application to the useful aims of mankind. But we do ask in addition that he shall be actuated primarily by motives other than profit, which is the driving force appropriate to trade and commerce. Over and above the resources of his intellect and experience he must, as Judge Wyzanski remarked in a recent address, be imbued with a desire to contribute to the common account.

This year (June, 1955) some 26,000 young men who in due time may enter employment as engineers will be graduated from our schools and colleges. Of these a smaller number, we may be sure, will ultimately attain the ranks of a profession. The degree conferred by a college upon a young graduate marks the faithful completion of a course of study; it does not in itself create an engineer. The license granted by a board of examiners establishes the experience and technical proficiency of the candidate, but he is not thereby invested with professional stature.

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(*Concluded on page 118*)

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ENGINEERING EDUCATION

(Concluded from page 116)

most complex society of all times and the demands that it makes upon men are infinitely diverse. There is no one plan of education best suited to all needs, and the strength of our American system of education lies in the rich variety of its forms. There is an insatiable need by industry for engineers with sound practical training, and there should be schools in adequate number to supply them. But there is a need, too, for young men prepared to rise to the most elevated ranks of their profession. Now it is my conviction that one and the same plan of engineering education cannot serve both the aims of immediate utility and the highest aspirations of the profession.

Engineering education is built upon mathematics and the physical sciences; with these must be fused the humanities as integral elements rather than peripheral – as the means to deepen the insight of the engineering student into the culture and problems of his society, and to create an awareness of his responsibilities and an understanding of the ethical principles upon which his decisions must rest. In this sense all subjects are professional, whether English or political economy, circuit analysis or fluid mechanics, for all contribute to the making of a professional man. In the hands of wise and gifted teachers, all these are liberal subjects, for each in its own way may open and free the mind.

If there is one thought that the writer would like to urge, it is that we who are of the colleges and universities of the country lift our eyes to the challenge of undergraduate professional education. It is an education designed for both competence and conscience. It is distinguished less by content than by an attitude – a concern for principles, a ceaseless reaching down for fundamentals, for the essence of the matter. Unremittingly it cultivates a taste for excellence, for the first-rate, and the capacity to discern it. And with all this there must be an unflagging attention to the development of a sense of responsibility and dedication.

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SMALLPOX

(Continued from page 98)

Arnold gravely wounded, and the Americans evacuated Canada.

Inoculation continued to be employed as a fairly effective preventive of smallpox until the turn of the Eighteenth Century, when it was superseded by a newer and better method. In England a country doctor named Edward Jenner had observed that dairy maids who contracted cowpox from cattle were immune to human smallpox. In 1796 he deliberately vaccinated a young boy, James Phipps, with cowpox from the infected hand of a dairy maid. A few weeks later the boy was inoculated with true smallpox material, but did not get the disease. After further tests, Jenner wrote a paper on this subject in 1798, a little pamphlet which aroused much interest on both sides of the Atlantic. From 1799–1801 more than 3,000 persons were successfully vaccinated in London.

The first proponent of this new method in America was Dr. Benjamin Waterhouse, Professor of Physick at Harvard, who published an article on the subject in the *Columbian Centinel* in Boston on March 16, 1799. On July 8, 1800, Dr. Waterhouse performed the first vaccinations in this country, using seven members of his own household as the subjects. None of these contracted smallpox when later exposed to it. Dr. Waterhouse sent some of his vaccine to President Thomas Jefferson, whose physician inoculated the members of the President's family at Monticello. The doctor, strongly supported by Dr. James Jackson, also managed to wheedle from the Boston Board of Health a public endorsement of the process. This board, one of the first in the United States, had been organized in 1799 with Paul Revere as president.

Although here at last was a practical and proven method for the conquest of a terrible disease, tremendous opposition to vaccination immediately arose among the ignorant, the prejudiced, and the deluded. Cotton Mather had died in 1728 and was no longer available to conduct a crusade among the clergy, many of whom were against vaccination. Despite much ill-considered opposition, Massachusetts adopted a vaccination law in 1809, and gradually most of the states followed this example, making vaccination a prerequisite for attendance at school, or requiring it in the general population when small-

(Continued on page 120)

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SMALLPOX

(Continued from page 119)

pox was present or threatening. The disease continued, however, to be a serious menace in this country until well into the Twentieth Century. In 1840, for example, smallpox was responsible for 20 per cent of all deaths of children under 10 years of age. As late as 1933, there were about 13,000 cases in the U.S., mostly in states without compulsory laws.

In 1902 smallpox was, as usual, prevalent in Cambridge, Mass. Acting pursuant to state law, the city board of health passed a resolution requiring vaccination of all persons who had not been successfully vaccinated since 1897. A citizen by the name of Henning Jacobson refused to comply, was haled into court and fined, an action upheld on appeal by the Supreme Judicial Court of Massachusetts. The case was then appealed on constitutional grounds to the Supreme Court of the United States. In a noteworthy decision handed down in 1905 by Mr. Justice Harlan, this court sustained in every particular the legal principle of compulsory vaccination. By an interesting coincidence, the son of this Henning Jacobson is now an esteemed neighbor of the author in Newtown, Conn.

In the course of a lifetime career in public health, I have had to mingle with many cases of dangerous diseases, but the last time I saw a case of smallpox in this country was in 1918. As sanitary inspector for the military forces in the extra-cantonment area of

(Concluded on page 122)

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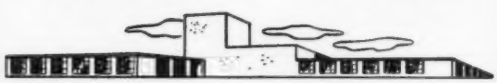

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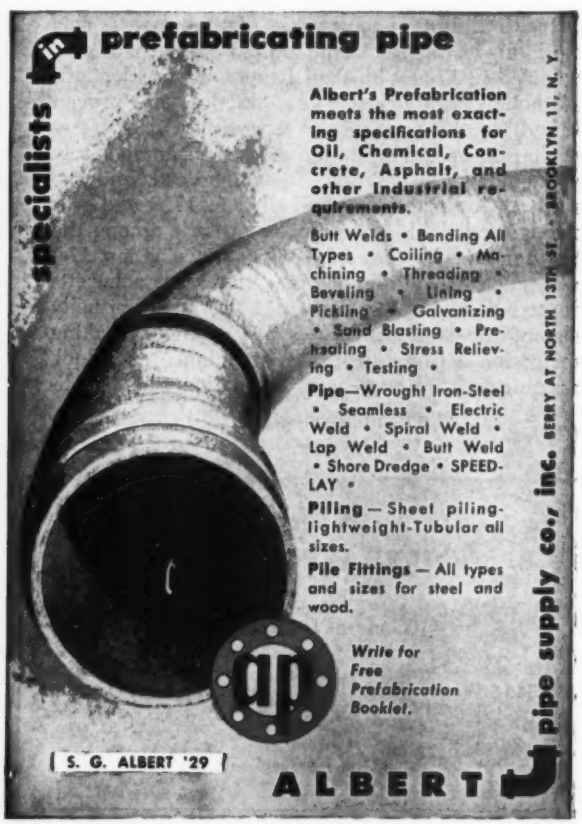
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SMALLPOX

(Concluded from page 120)

Camp Sherman at Chillicothe, Ohio, I accompanied the city health officer to a small brick house in the slums. In the fetid living room a woman lay on a couch, covered by a piece of old carpeting, while on a cot was a child under a piece of dirty burlap. When pulled back, these covers revealed two full-blown cases of malignant smallpox. Since this is the most contagious of all diseases, I immediately went out and had myself vaccinated, knowing that successful vaccination within five days of exposure is an absolute preventive. I did not get the disease. In all, I have been vaccinated some 10 times, without any ill effects, and with a wholesome sense of security, especially when traveling in foreign countries where this disease is still widely prevalent. American tourists returning from certain foreign lands, Mexico for instance, must show a recent vaccination certificate in order to be readmitted.

Smallpox may be almost a forgotten disease in this country, but lack of familiarity with it should not breed contempt. A few years ago there was a smallpox scare in New York City, when several cases were introduced from Mexico, but the potential epidemic was nipped in the bud by a widespread vaccination campaign. About 25 years ago there was a severe epidemic of black (hemorrhagic) smallpox in Detroit. History sometimes repeats itself with maladies which are thought to have been conquered. A virus may lie dormant while the populace is lulled into a false sense of security, then it appears in a more virulent form than ever before. That is why vaccination and revaccination is still, and probably always will be, a desirable procedure.

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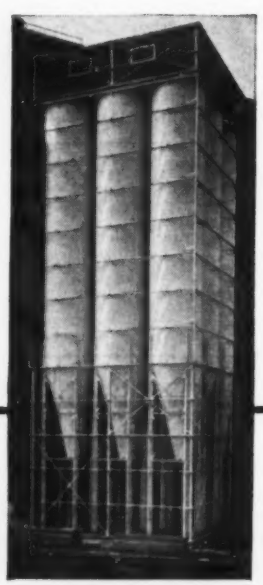

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